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VICTORIA

PAPERS & PROCEEDINGS

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OF TASMANIA

FOR THE YEAR

1931

(With 19 Plates and 20 Text Figures)

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The responsibility of the statements and opinions in the following papers and discussions rests with the individual authors and speakers; the Society merely places them on record.

THE ROYAL SOCIETY OF TASMANIA

PAPERS AND PROCEEDINGS, 1931.

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THE ROYAL SOCIETY OF TASMANIA

The Royal Society of Tasmania was founded on the 14th October, 1843, by His Excellency Sir John Eardley Eardley Wilmot, Lieutenant Governor of Van Diemen's Land, as "The Botanical and Horticultural Society of Van Diemen's Land." The Botanical Gardens in the Queen's Domain, near Hobart, were shortly afterwards placed under its management, and a grant of £400 a year towards their maintenance was made by the Government. In 1844, His Excellency announced to the Society that Her Majesty the Queen had signified her consent to become its patron; and that its designation should thenceforward be "The Royal Society of Van Diemen's Land for Horticulture, Botany, and the Advancement of Science."

In 1848 the Society established the Tasmanian Museum; and in 1849 it commenced the publication of its "Papers and Proceedings."

In 1854 the Legislative Council of Tasmania by "The Royal Society Act" made provision for vesting the property of the Society in trustees, and for other matters connected with the management of its affairs.

In 1855 the name of the Colony was changed to Tasmania, and the Society then became "The Royal Society of Tasmania for Horticulture, Botany, and the Advancement of Science."

In 1860 a piece of ground at the corner of Argyle and Macquarie streets, Hobart, was given by the Crown to the Society as a site for a Museum, and a grant of £3,000 was made for the erection of a building. The Society contributed £1,800 towards the cost, and the new Museum was finished in 1862.

In 1885 the Society gave back to the Crown the Botanical Gardens and the Museum, which, with the collections of the Museum, were vested in a body of trustees, of whom six are chosen from the Society. In consideration of the services it had rendered in the promotion of science, and in the formation and management of the Museum and Gardens, the right was reserved to the Society to have exclusive possession of sufficient and convenient rooms in the Museum, for the safe custody of its Library, and for its meetings, and for all other purposes connected with it.

In 1911 the Parliament of Tasmania, by "The Royal Society Act, 1911," created the Society a body corporate by the name of "The Royal Society of Tasmania," with perpetual succession.

The object of the Society is declared by its Rules to be "the advancement of knowledge."

His Majesty the King is Patron of the Society; and His Excellency the Governor of Tasmania is President.

NATIONAL MUSEUM VICTORIA

PAPERS
OF
THE ROYAL SOCIETY OF TASMANIA
1931

TASMANIAN COLLEMBOLA OF THE FAMILY SMINTHURIDÆ.
(GLOBULAR SPRINGTAILS)

By
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Plate I. and Six Text-figures.
(Read 13th July, 1931)

The Collembola, or Springtails, are one of the lesser known orders of the Insecta, differing from all others in possessing not more than six abdominal segments and in having in most species a peculiar forked spring by which they are able to leap with great agility.

They are a very primitive group of insects, entirely apterous, and have recently been shown to be the earliest fossil insects.

The Collembola have been divided by Börner into two suborders, (1) the ARTHROPLEONA, comprising the more elongate forms in which the segmentation of the thorax and abdomen is well defined, and (2) the SYMPHYPLEONA or globular forms with little or no segmentation.

The latter suborder contains two families, the NEELIDÆ, a group of peculiar insects with antennæ much shorter than the head and inserted low down on the face, and the SMINTHURIDÆ, with antennæ longer than the head and situated well up towards the vertex.

To this latter family belong most of the Collembola which are of serious economic importance. Owing to the immense numbers in which they usually occur the amount of damage caused to clover and other crops is often of very serious importance.

During the past twelve months I have received from Dr. R. J. Tillyard, Chief of the Division of Economic Entomology of the Australian Commonwealth Council for Scientific and Industrial Research, several collections of SMINTHURIDÆ made by himself, Mr. H. M. Nicholls, Microbiologist, Department of Agriculture, Hobart, and Mr. R. A. Scott, Agronomist, Department of Agriculture, Launceston, in various parts of Tasmania.

These collections proved to be of the greatest interest, and I desire to record my thanks to the collectors for the opportunity of studying the contents. Altogether, seven species were obtained, of which two are new to science, while of the remainder four are new to Australia. These four, together with the previously known and abundant *Sminthurus viridis*, Lin., have possibly been introduced from Europe. It is important to notice that, as in the case of the two new forms, which are probably indigenous to the continent, they may under suitable conditions become a pest.

Of the morphological characters used in the identification of these insects the furca or spring is one of the most important. This organ is attached to the fourth or fifth abdominal segment. It consists of a basal piece, the *manubrium*, from which arise two arms, the *dentes*, each of which carries a terminal piece called the *mucro*. When the insect is in repose the spring is folded under the body, being held by a catch. Ventrally from the first abdominal segment arises an organ termed the *ventral tube*. From the basal portion of this two long filaments can be extruded at will. These may or may not have wart-like tubercles on the walls.

The feet exhibit many features of specific and generic value. Normally there are two claws, an upper or larger and a lower or smaller. The lower claw is sometimes regarded as an *empodial appendage* and may be wanting. The upper has the inner edge sometimes toothed or plain, and in some cases the claw is enclosed in a sheath or *tunica*. The lower claw may have both an inner and an outer lamella, and in most species of this family there arises apically or subapically a fine bristle. On the tibiotarsus just above the claw may be a number, usually three or four, of long clavate bristles.

The eyes when present consist of from one to eight simple ocelli on each side usually on a patch of black pigment.

The antennæ in the SMINTHURIDÆ are four jointed, although the apical joint is often secondarily divided.

Key to the Genera of SMINTHURIDÆ.

I. Ventral tube with smooth walls.

Subfam. SMINTHURIDÆ C.B.

(a) Abdom. V. & VI. fused. Filaments of ventral tube shorter than basal part. Male antennæ morphologically different from that of female. Female without genital appendages.

Tribe SMINTHURIDINI C.B.

Genus *Sminthurides* C.B.

(b) Abdom. V. & VI. distinctly differentiated. Filaments of ventral tube long. Antennæ alike in both sexes. Female with genital appendages.

Tribe KATIANNINI C.B.

1. Ant. IV. not subdivided. Genus *Sminthurinus* C.B.

   Ant. IV. distinctly subdivided. 2.

2. Ant. III. normal. Genus *Arrhopalites* C.B.

   Ant. III. with a peculiar outer peg-like organ; long and strong setæ on ant. I., II., and III., some of which lie flat. Strong spines also above and between eyes. Mucrones with three unequal lamellæ.

   Genus *Katianna* C.B.

II. Ventral tube with warted walls.

A. Antennæ bent between joints II. and III., IV. shorter than III.

Subfam. DICYRTOMINÆ C.B.

1. Upper claw without tunica. 2.

   Upper claw with tunica. Dentes without serrated setæ. Ant. III. and IV. not subdivided.

   Genus *Dicyrtomina* C.B.

2. Ant. III. and IV. not subdivided, at most with slight indications of ringing. Dentes with or without serrated setæ.

   Genus *Dicyrtoma* Bourl., C.B.

   Ant. III. and IV. or only IV. (distally) distinctly subdivided. Dentes with serrated setæ.

   Genus *Ptenothrix* C.B.

B. Antennæ bent between III. and IV., IV. longer than III.

Subfam. SMINTHURINÆ C.B.

(a) Tibiotarsus with 2-3 short adjacent clavate hairs. Upper claw without tunica.

Tribe BOURLETIELLINI C.B.

1. Hind tibiotarsus with an inner series of 5-6 spines close together which may be serrated or not. These are termed by Börner "Rastraldornen."

Genus *Rastriopes* C.B.

Hind tibiotarsus without the above. 2.

2. With an abnormal protuberance, single or double, in the middle of the dorsum. Lower claw replaced by a modified clavate hair.

Genus *Corynephoria* Absolon.

Without the above dorsal protuberance. With or without a lower claw. 3.

3. Genital segments alike in both sexes.

Genus *Deuterosminthurus* C.B., Linnan.

Genital segments of male with a clasping organ of hooks and curved bristles.

Genus *Bourletiella* Banks.

(b) Tibiotarsus without adjacent clavate hairs, or, if present, then outstanding. Upper claw with or without tunica.

Tribe SMINTHURINI C.B.

1. Ant. III. in proximal half with four strong bristles, stronger than the rest and in the form of a square. Also a fifth short bristle. 2.

Ant. III. with three characteristic bristles but not stronger than the rest. Mucronal bristle absent. Claw with a distinct tunica. Tibiotarsus without clavate hairs.

Genus *Sphyrotheca* C.B.

2. Furcal segment dorsally with two roundish glandular papillæ. Mucronal bristle present. Claw with distinct outstanding tunica.

Genus *Allacma* C.B.

Furcal segment without papillæ. Mucronal bristle present or absent.

Genus *Sminthurus* (Linn.), Lubbock.

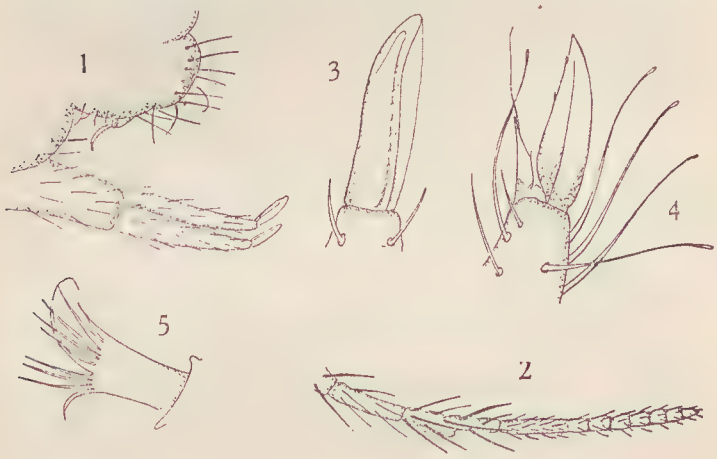
Description of the known Tasmanian species of SMINTHURIDÆ

Genus KATIANNA C.B.

KATIANNA AUSTRALIS n. sp.

(Plate I., fig. 1. Text-fig. I., 1-5.)

This species is closely allied to the type of the genus, *K. cobold*, described by C. Börner from S. America. From *K. oceanica*, the only other Australian species, which was described by Schött from North Queensland, it differs in colour and markings, in the ratio of antennal segments, in the number of clavate hairs on the tibiotarsus, and in the structure of the claws.



Text-fig. I.:—*Katianna australis* n. sp. 1, Anal segments and furca of female, showing genital appendage. 2, Antenna. 3, Mucro from side. 4, Tip of tibiotarsus, side view. 5, Female genital appendage from above.

From the specimens sent to me, this species appears to occur only in the Stanley Area of Tasmania.*

Diagnosis: Length 1.75 mm. Colour yellowish with heavy dark mottling on dorsum and extending down the sides. Anal segments rather more yellow. Head and face with a dark patch between the antennal bases and another below extending to the mouth. Eye patches black. Antennæ dark

*Since recorded as widespread on the mainland of Australia; hence the specific name.

blackish green, basal joints a little lighter. Venter, legs, and furca yellowish.

Eyes eight on each side on black patches, behind and between which are a number of strong curved spine-like setæ. Antennæ twice as long as head, diagonal, joints relatively 1 : 2½ : 2½ : 5½; last joint with 4-5 secondary divisions in distal half. Ant. III. with an outer peg-like organ at the middle. Ant. I., II., and III. with particularly long and strong setæ, the longest of which are half the length of joint and lie flat. Ant. IV. with the usual whorls of fine hairs.

Legs: Tibiotarsus with 4-5 clavate hairs. Upper claw strong, almost as long as the mucro, with two inner teeth, one just beyond the middle, the other near the tip. Lower claw about half the length of upper, with broad inner lamella and long subapical seta which reaches the tip of upper claw, inner angle with two fine teeth. Claws similar on all feet.

Furca comparatively short. Manubrium : dentes : mucro = 1 : 2 : ¾. Mucro with unequal lamellæ as in *Bourletiella*, the inner lamella with coarse flat teeth.

Genital appendages of female strongly branched.

Tenaculum with curved basal piece, at tip of which are two setæ, rami with three barbs.

Clothing of numerous strongly curved setæ.

Genus DEUTEROSMINTHURUS C.B.

DEUTEROSMINTHURUS BICINCTUS Koch,

form REPANDUS Agren.

(Plate I., fig. 2.)

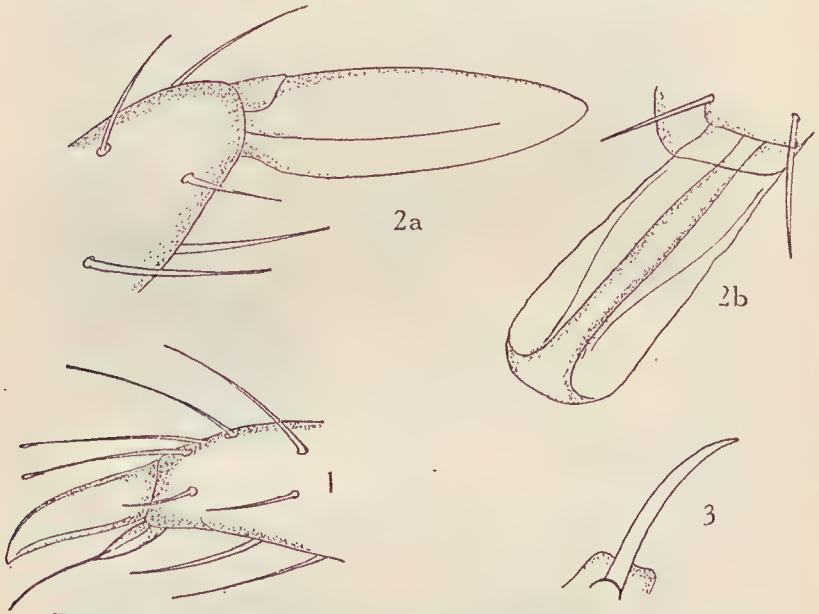
This small species was represented in the collections only by specimens from Glenorchy, Tasmania. It is a curious saddle-shaped insect, and on this account easily recognised.

It measures barely 1 mm. in length and varies very much in colour. The type form of the species is yellow with two broad blackish-brown cross bands. In *repanda* it is entirely yellow, tending to orange on the dorsum. The type as well as the entirely black form *pallipes* Lubbock, may be expected to occur in Australia. They are all common clover insects in Europe.

DEUTEROSMINTHURUS CINQUEFASCIATUS Krausbauer.

(Plate I., fig. 3. Text-fig. II., 1-3.)

This is a rather larger species which is very distinctive on account of the white cross bands. In Tasmania it appears to be already known as the "Banded Springtail." All the



Text-fig. II.:—*Deuterosminthurus 5-fasciatus* Krbr. 1, Tip of tibiotarsus from side. 2, Mucro (a) from side, (b) above. 3, Female genital appendage.

specimens of this species, except a solitary one from Gawler, were from the Forth Area.

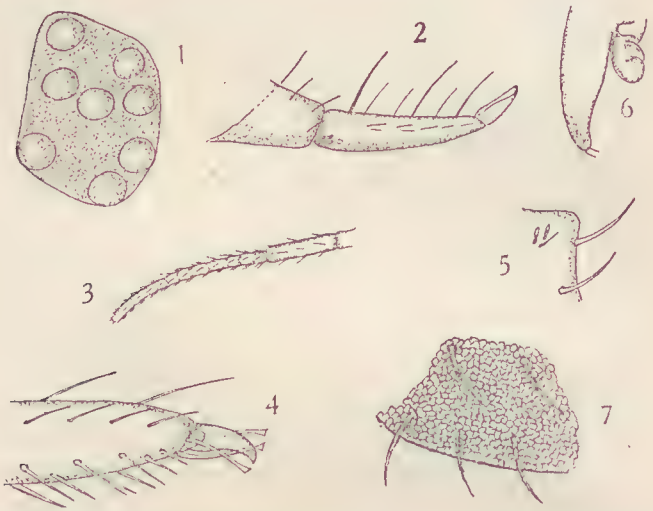
It is perhaps with some doubt that these specimens are referred to this species, which has only been recorded from the original locality at Weilburg a.d. Lahn in Germany by Krausbauer in 1898. It does not appear to have been observed since, but the somewhat brief account agrees in details with the Tasmanian material.

DEUTEROSMINTHURUS OBSCURUS n. sp.

(Plate I., fig. 4. Text-fig. III., 1-7.)

Four specimens of this new species were taken attacking the tops of young carrots at Scottsdale, Tasmania, 3/12/26.

It is a dark form in which the pigmentation is carried on to the furca and legs. In outward appearance it somewhat resembles *D. bicinctus f. pallipes* Lubbock. From other Tasmanian species of the genus it is easily separated by the absence of the lower claw.



Text-fig. III.:—*Deuterosminthurus obscurus* n. sp. 1, Ocelli and eye patch. 2, Furca. 3, Antenna. 4, Tip of tibiotarsus. 5, Antennal III. organ. 6, Tenaculum. 7, Dorsal cuticle and setæ.

Diagnosis: Size 1.3 mm. Colour entirely black except for the vertex of the head, antennæ, legs, and furca which are only a shade lighter, still retaining a deep pigmentation.

Eyes eight on each side. Head : ant. I. : II. : III. : IV. = 17 : 2½ : 5 : 5 : 13; ant. IV. with 16-20 secondary rings and with a minute terminal knob. Ant. III. organ as in fig. III., 5.

Legs normal. Claws alike on all feet, without inner or outer teeth, one-third the length of mucro. Lower claw wanting. Clavate tibiotarsal hairs 3-3-2, broadly spatulate at tips.

Body hairs long, finely ciliated and numerous. A pair of sensory setæ (bothriotrichia) are present on each side of the anal segment, and there are three others in a diagonal line on each side of the abdomen. The cuticle is strongly granular. Female genital appendages?.

Fig. 1. *Katianna australis* n. sp. Lateral view.
Fig. 2. *Deuterosminthurus bicinctus f. rotundus* Agren. Lateral view.
Fig. 3. *Deuterosminthurus cinquefasciatus* Krausbr. Lateral view.
Fig. 4. *Deuterosminthurus obscurus* n. sp. Lateral view.
Fig. 5. *Bourletiella arvalis* Fitch. Lateral view.
Fig. 6. *Bourletiella hortensis* Fitch. Lateral view.
Fig. 7. *Sminthurus viridis* (Linn.) Lubb. Lateral view.

TIONAL

Genus BOURLETIELLA Banks.

BOURLETIELLA ARVALIS Fitch.

1863. Syn. *B. lutea* (Lubb.) Agren. (1867) 1903.

(Plate I., fig. 5. Text-fig. IV., 1-5.)

This is a very common species of clover springtail throughout Europe. Together with the next species it has been recorded from England and America as damaging young root crops, causing the effect known as "strangle neck."

Text-fig. IV.:—*Bourletiella arvalis* Fitch. 1, Spines on anal segment of male. 2, Mucro from side. 3, Tip of tibiotarsus. 4, Female genital appendage from side. 5, Dorsal setæ.

It has only recently been shown by Dr. Folsom (*A List of the Insects of New York State*, Cornell Univ. Agric. Exper. Sta., Mem. 101, 1928) that this species, which has previously been known as *B. lutea* Lubbock, is synonymous with *B. arvalis* Fitch.

While differing in its lighter colouring from the following species it can be definitely separated in the male sex by the form of the clasping organ on the anal segments, and in the female by the form of the genital appendages (see text figures).

In Tasmania it occurs in the Stanley, Franklin, Longford, Forth, Gawler, and Forest Areas.

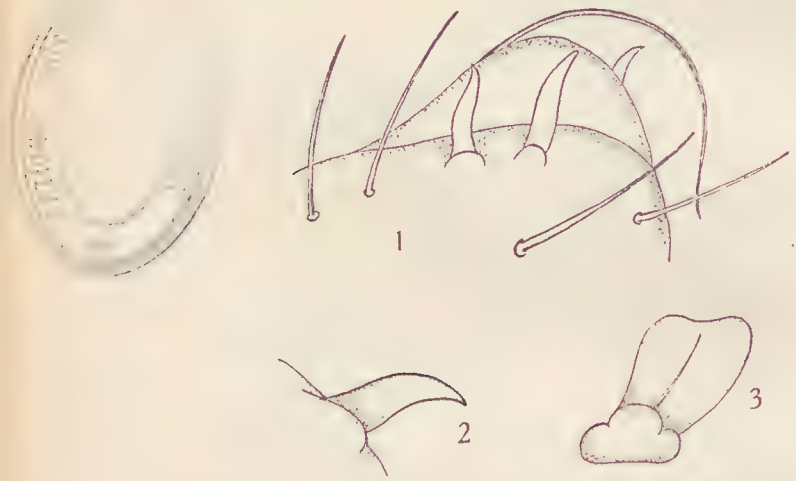
BOURLETIELLA HORTENSIS (Fitch) Folsom.

Syn. *pruinosa* C.B.

(Plate I., fig. 6. Text-fig. V., 1-3.)

This species has been considered by some authors as only a dark form of the preceding, but, as stated above, it differs very markedly in the secondary sexual characters. It occurs on root crops in America and Europe, and has also been recorded from Japan.

In Tasmania it has been taken in the Forth, Gawler, and Stanley Areas.



Text-fig. V.:—*Bourletiella hortensis* Fitch. 1, Spines on anal segments of male. 2, Female genital appendage from side. 3, Female genital appendage from above.

Genus SMINTHURUS (Linn.) Lubbock.

SMINTHURUS VIRIDIS (Linn.) Lubb.

(Plate I., fig. 7. Text-fig. VI., 1-3.)

This is the common Clover Springtail or Lucerne Flea, and everywhere appears to be the dominant springtail of grass and clover land. In Tasmania it is much more abundant than in Europe, as also where it occurs in other parts of Australia.

Text-fig. VI.: *Sminthurus viridis* Linn. 1, Mucro from side. 2, Tip of tibiotarsus. 3, Female genital appendage from side.

It is a species much given to colour variation, and many forms have been given varietal names. It can be definitely identified microscopically by the lack of clavate tibiotarsal hairs, the strong mucronal bristle, and the distinct beaded tunica on the upper claw.

ABORIGINAL ROCK-CARVINGS ON THE NORTH-WEST COAST OF TASMANIA.

By

A. L. Meston, M.A.

Plates II.-VIII.

(Read 13th July, 1931.)

Many descriptions have been given of aboriginal art in various parts of Australia, but accounts of the skill of the Tasmanians in drawing and carving have been extremely meagre. In recent years, however, a number of rock carvings have been discovered in one locality on the North-West Coast, and it is the purpose of this paper to describe them. Before doing this, I intend briefly to review all previous descriptions of the art of the Tasmanian aborigines.

Péron, who visited Tasmania in 1802 as naturalist on the *Géographe*, gave us the first account of aboriginal drawings. On the under surface of some of the best and largest pieces of bark covering a burial mound discovered by him at Oyster Bay, he found "some characters crudely marked, "similar to those which the aborigines tattooed on their "forearms."

In 1857 Daniel Bunce, describing his journey through Middlesex Plains, the Vale of Belvoir, and over the Black Range, makes a reference to aboriginal drawings. "Some "time previously," he writes, "two carts belonging to the "V.D.L. Co. had passed over this ridge each drawn by six "oxen with their drivers. It appears that some natives had "observed this, and a short time afterwards, one of the "Company's servants passing that way, found in one of their "rudely constructed huts, a piece of the bark of a tree with "a rough drawing of the whole scene. The wheels of the "carts, the bullocks drawing them, and the drivers with their "whips over their shoulders were all distinctly depicted in "their rude but interesting manner." This is obviously a reference to the taking of two carts to the Surrey Hills in 1828 by the V.D.L. Co., the first occasion that wheeled vehicles had ever passed that way.

Bonwick says that Mr. G. A. Robinson saw drawings of men and women with some curious hieroglyphics, like the totems of tribes, when he was on the West Coast in 1831. He also mentions "the red hand marked on trees and rocks

"alike in Tasmania and Australia," and gives "some rude "sketches of men and animals with five drawings as seen by "Mr. Commissary Browne on a tree representing the sun, "the moon, some snakes, and five persons in a boat."

Dr. Ross relates the discovery of "some rude drawings "of human figures, of squares and circles scratched on the "inner side of the bark of a hut in the valley of the Ouse."

Calder writes of some huts and "on the bark that "covered them, were some extraordinary charcoal drawings: "one representing two men spearing an animal, which from its "erect position was I presume meant for a kangaroo: though "the artist, by a strange oversight, had forgotten the animal's "tail and had made the forelegs about twice as long as the "hinder ones. There was also an outline of a dog, and an "emu, really not badly done; and some other designs the "exact meaning of which I was not able to make out." Elsewhere he states: "But the chef-d'œuvre was a battle piece—"a native fight—men dying and flying all over it."

All of these Ling Roth mentions, but there is another reference which escaped his notice. In February, 1827, Henry Hellyer, architect and surveyor of the V.D.L. Co., came upon two native huts in the Surrey Hills. "In one of "the huts," he writes, "I saw a drawing of the moon done "with charcoal, upon the inside of one of the slabs of bark "which formed the hut: and regarding it as an evidence "of there being artists among them I cut out the piece, and "placed it carefully between two pieces of bark in my knap-"sack." He does not say why he thought the drawing was a representation of the moon, but I imagine it was crescent shaped and left little doubt as to its meaning.

Such then has been the extent of our knowledge of the artistic efforts of the Tasmanian aborigines, so scanty that Ling Roth goes so far as to say, "The whole question of the "existence of drawings by aborigines before European "advent is practically an open one for the evidence is not "satisfactory." "It should be mentioned," he continues, "that "Milligan in his vocabulary gives Depict—draw in char-"coal: 'macoolana.' This at first sight seems conclusive. "But in the same vocabulary, he gives other words for "objects not known to the natives in their wild state—e.g., "'bread,' 'spaniel,' 'gun,' and 'gunpowder.'"

Before discussing the carvings themselves it will be well to describe their situation. Where the Mersey runs into Bass Strait the western shore is prolonged into a rocky headland, known as the Bluff. This promontory, very low

where it joins the mainland, extends seawards for 633 yards, and runs up to a height of 74 feet. The remains of a fairly extensive midden in the south-west corner give ample evidence of aboriginal occupation. Until quite recent years the place remained very much as it was when the native aborigines frequented it. A sandbank covered with booby-allas afforded shelter from all winds, and behind it lay a little fresh water lagoon fringed with tea trees, while in front a bank of shingle provided ample material for their stone implements. The lagoon is now filled in, the tea trees have been cut down, and the sandbank is in part removed, leaving little of the original charm.

While it is impossible to say definitely what the carvings represent, they seem to fall into two classes, one depicting natural objects, the other signs and patterns. And, moreover, it is impossible to say whether what appears to us as a sign or pattern may not be a conventionalised drawing of some object well known to the aboriginal. The natural objects are a fish, a snake, a bird's head, a leaf, and a haliotis shell. The signs and patterns include circles, concentric circles, large ovals with smaller ovals set within, and ovals each with a salient which bears a striking likeness to a specialised type of aboriginal stone scraper. Occasionally, the artist has made use of a natural unevenness in the rock to make his design stand out the more, but cracks in the rock have not been used. In every design I have examined the natural cracks are transverse to the carvings. This is particularly noticeable in plate IV., figure 2, and plate VII., figure 2.

The rock of which the Bluff is composed is diabase, and it is in this hard, refractory material that the engravings are made. All are cut on horizontal faces of rock and are distributed over the whole area of the promontory. But although I have made a careful search of the north coast from West Head to Circular Head I have found none elsewhere. The number of carvings known to me is seventy-five, but there is ample evidence from remnants that at one time the number was much greater. The condition of these extant varies greatly. Some are little more than mere lines, while others are deeply incised. On the seaward face of the headland, swept by spray every storm, weathering is rapidly destroying them, and since I first saw them in February, 1929, five have, by the flaking of the rock surface, completely disappeared. Several others will disappear this winter. The effects of weathering are well shown in plate III., figure 1, and plate IV., figure 1.

A remarkable feature is the depth of some of the carvings in such hard material. In this respect they are in striking contrast with carvings found on the mainland of Australia, which are for the greater part cut in soft limestone, slate, or sandstone, and are not very deep. Of those found on the Bluff, the deepest, the haliotis shell, is 58 millimetres, another reaches a depth of 26 millimetres, another 22, another 21, another 18, two others 17, three others 16, and another 15 millimetres. The great depth combined with a comparatively narrow width is a remarkable feature of many of the carvings. What tools the makers of these figures used is a puzzle. A very careful search, however, has failed to reveal any tools of the workers; but they would seem to have been made, not by rubbing, but by a pointed piece of quartzite, breccia, or similar hard material driven by a stone used as a hammer.

That the carvings exist at the Bluff, and, to the best of our knowledge, nowhere else, is remarkable, but a possible explanation is that either this area was sacred, or was a place of assembly and consultation. For either purpose it is admirably adapted. Calder describes a meeting place and a ceremonial tree west of the Tamar, only some thirty miles away, and it seems that the Bluff was in some way of grave importance to the aborigines.

In getting photographs the chief difficulty was to prevent distortion, but this was overcome by using an optipod which enabled the camera to be focused from directly above the figures. Several when first seen were encrusted with lichens, which it was necessary to clear away with a brush.

The important question of the cause of the carvings remains to be discussed. It is generally recognised that art for art's sake is not known to primitive peoples. All art was utilitarian, and took its rise from a belief in magic. This is true of the prehistoric paintings of the caves of Altamira, of the drawings and sculptures in the caverns of the Cantabrian Pyrenees, of the Haute Garonne, and of the Dordogne. It is true of the natives of North-West Australia. All the pictures made by the Worrora tribe except those of the human being represent some article of food, and even those of the human being "the Wonjuna" are made to ensure that rain will not fail. "The belief is," writes Mr. J. R. Love, "that "wherever the picture of an object of food is preserved in a "picture cave, there that object will continue to flourish and "increase. An object that recurs not infrequently, and that "appears meaningless, till explained, is the liver of a sting-

"ray, a favourite article of food. When explained as the "liver it is seen to be quite a fair picture of a liver. So also "with some of the edible roots. But quite a number of the "pictures are conventional representations of some article of "food, or some part of the body, which do not to the Euro-"pean eye bear any resemblance to the object represented." If this material outlook is true of so many primitive races it is fair to suppose it true of our aborigines. To them art was not a means of self-expression, but a weapon to encounter and overcome the Great Unknown.

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Fig. 1. View of Bluff from the air.

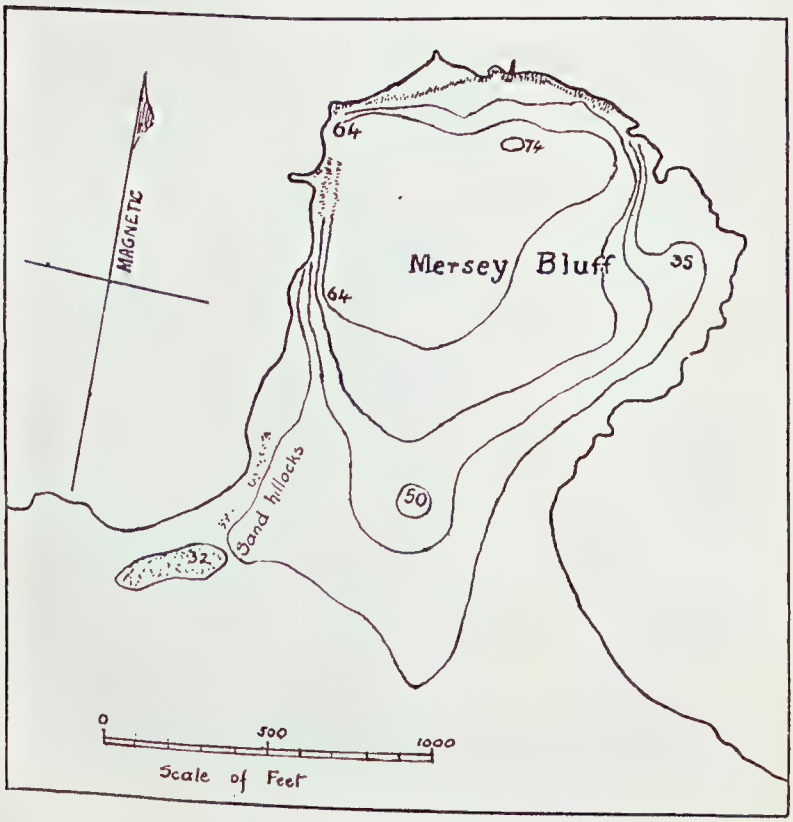

Fig. 2. Contour Map of Bluff.

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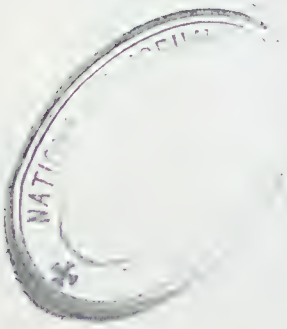
Fig. 1. Fig. 2. Fig. 3. Fig. 4.

Fig. 5. Fig. 6. Fig. 7.



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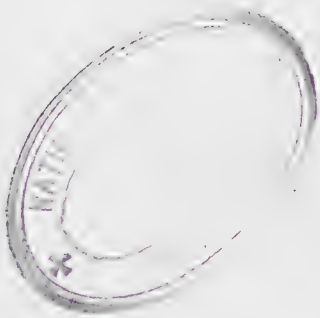

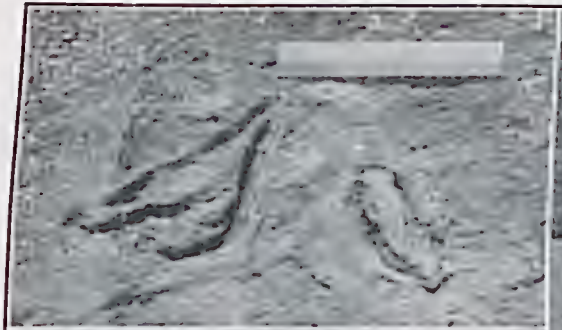

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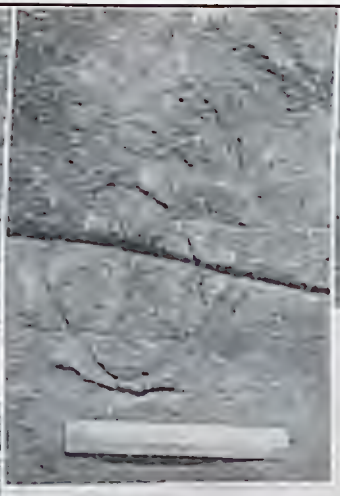

Fig. 2.

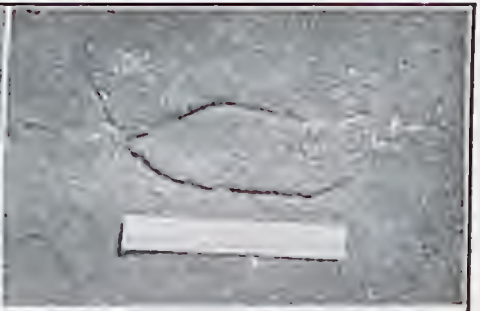

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Fig. 6.

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Fig. 1.

Fig. 2.

EXPLANATION OF PLATES.

PLATE II.

The rule shown is 6 inches long.

Fig. 1.—A view of the Mersey Bluff from the air showing its relation to the surrounding country. The part now appearing as fields was originally a dense tea tree (melaleuca) scrub. The midden is behind the sandy beach at the base of the bluff, at the bottom of the picture. In the middle background is seen the R. Mersey, and part of the town of Devonport.

Fig. 2.—Most of the carvings are on the step northern face of the headland or within the 64 feet contour. It is on the northern face that weathering is most pronounced.

PLATE III.

Fig. 1.—Major axis 14.25 cm.: greatest depth, 15mm. The effect of weathering is clearly seen.

Fig. 2.—This and fig. 7 are on the same rock within a few feet of each other.

Fig. 3.—Length, 12 cm.; greatest width, 9.9 cm.; least width, 6.3 cm.; greatest depth, 10 mm., fading away to zero at narrowest part.

Fig. 4.—Larger oval, 8 cm. long, 6.45 cm. wide; smaller oval, 5.9 cm. long, 4 cm. wide. Greatest depth, 3 mm.

Fig. 5.—Major axis, 6.8 cm.; minor axis, 4.3 cm.

Fig. 6.—Length, 10.2 cm.; breadth, 5.59 cm.

PLATE IV.

Fig. 1.—Major axis, 9.85 cm.; minor axis, 8.15 cm. This is uniformly deep, and varies in depth from 16 to 21 mm. The extent and manner of weathering are clearly seen on the right of the carving.

Fig. 2.—Apparently a conventionalised fish. The manner in which the natural cracks of the rock run transverse to the carvings is clearly shown. Length, 32.4 cm.; greatest width, 15.4 cm. At this point there are two deep pits that may have been intended for eyes. Distance between them, 5.55 cm. Greatest depth, 16 mm., is at the top of the figure. Depth of deepest eye pit, 15.5 mm.

Fig. 3.—A very fair representation of the appearance of a Tasmanian snake when coiled. Length along the top, 7.8 cm. Width of the top of the groove at its deepest

part, 5mm., tapering to 1.5 mm. at the bottom. Greatest width of the part representing the head, 2.3 cm.; length of head, 6.35 cm. Length of figure, 10.35 cm. Greatest depth, 17 mm. A great part of this figure is from 15 — 16 mm. in depth.

Fig. 4.—Diameter of the whole carving, 10.65 cm. Major axis of large inner oval, 7 cm.; of small inner oval, 3.8 cm. This is a common form.

Fig. 5.—Major axis, 6.9 cm.; minor axis, 6 cm. Depth, 3 mm.

Plate V.

Fig. 1.—A group of carvings, one of which bears a striking resemblance to a bird's head. The deepest figure possesses the characteristic salient of many carvings. Two feet away on the same rock, is another carving, not shown in the photographs, smaller but of similar design. Length, 13.5 cm.; greatest depth, 17 mm.

Fig. 2.—A deeply incised carving reaching a depth of 26 mm. This seems to be of the same type as Figs. 1 and 4, plate III., with part of the circumference incomplete. Greatest length, 20.8 cm. Length of small oval, 10.2 cm.; width, 6.35 cm. Greatest depth, 26 mm.

Fig. 3.—The only carving that assumes a cup and ring shape. Major axis, 17.8 cm.; minor, 12.7 cm. Greatest depth, 12.5 mm.

Fig. 4.—An incomplete oval. Major axis, 10.8 cm.; minor, 7.5. Uniformly deep. Greatest depth, 13 mm.

Fig. 5.—Length, 15 cm.; greatest breadth, 8 cm. This carving is very close to sea level. Deluged with spray every storm, it is rapidly becoming fainter.

Fig. 6.—Length, 22.85 cm.; greatest width, 8.9 cm. Greatest depth, 13 mm.

Plate VI.

Fig. 1.—Diameter of outer ring (incomplete), 24.4 cm., 22.85 cm. The direction of the natural cracks is clearly shewn. Breadth of groove at top, 21 mm.; at bottom, 4 mm. Greatest depth, 16 mm.

Fig. 2.—Greatest length, 20.3 cm. Major axis of oval, 8.9 cm.; minor axis, 7.6 cm.

Fig. 3.—Length of whole figure, 27.95 cm.; width, 20.8 cm. Major axis of pear-shaped figure, 18.3 cm.; minor axis, 15.75 cm.

Plate VII.

Fig. 1.—A leaf-like carving on the left, an irregular oval on the right; both deeply incised. The leaf is 18 mm. in depth, the oval 17 mm.

Fig. 2.—An excellent example of the way the natural cracks traverse the carvings. This carving is greatly weathered. Major axis of bigger oval, 24.1 cm.; minor axis, 14.6 cm. Major axis of smaller oval, 14 cm.; minor axis, 11.45 cm.

Fig. 3.—The salient is clearly shown. Length, 17.55 cm.

Fig. 4.—A deep crescent-shape groove. Distance from tip to tip of horns, 15.3 cm. Greatest depth, 22 mm.

Fig. 5.—A small weathered carving somewhat similar to fig. 2, plate V. Total length, 8.3 cm.; length of irregular oval, 5.95 cm.

Fig. 6.—Major axis of larger oval, 9.1 cm.; of smaller, 5.8 cm.

Plate VIII.

Both photographs are of the same figure. This is the largest and deepest of the carvings, and seems to be a conventionalised haliotis shell, the haliotis being a common article of food for the natives of this district. When found, the greatest part of this carving was covered with earth. This is the deepest carving yet found, reaching in the top left hand corner a depth of 58 mm. The width of the groove at the top of the widest part is 31.5 mm., but it tapers rapidly. The curl in the left hand segment reaches a depth of 40 mm. Major axis of curl, 15.8 cm. The figure is 58.4 cm. by 57.6 cm.

STUDIES IN TASMANIAN SPIDERS.

Part V.

(The Oonopidæ.)

By

V. V. Hickman, B.A., B.Sc.

Eleven Text-figures.

(Read 13th July, 1931.)

In the present paper three species belonging to the family *Oonopidæ* are described. The first is the hitherto unknown male of *Tasmanoonops alipes*, Hickman; the second a new species belonging to the genus *Oonopinus*, Simon; and the third a new species belonging to the genus *Orchestina*, Simon. As far as I am aware this is the first record of the two last-named genera occurring in Australia, either in Tasmania or on the mainland. A closely allied genus, *Australoonops*, has been found in Western Australia and *Orchestina* occurs in New Zealand.

Family OONOPIDÆ.

Subfamily Oonopinæ.

Genus *Tasmanoonops*, Hickman.

Tasmanoonops alipes, Hickman.

Female. See Proc. Roy. Soc. Tas., 1929, p. 98.

Male. Measurements in millimetres.

Total Length	4.1
Length of Cephalothorax	1.8
Width of Cephalothorax	1.4
Length of Abdomen	2.3
Width of Abdomen	1.4

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	2.0	0.8	1.8	1.8	0.7	7.1
2	2.2	0.8	1.8	1.5	0.7	7.0
3	1.9	0.7	1.4	1.4	0.6	6.0
4	2.4	0.7	1.9	1.9	0.7	7.6
Palpi	0.9	0.4	0.3	—	0.7	2.3

Cephalothorax: Yellowish brown; strongly narrowed in front, rounded at the sides and emarginate in rear. Longer than wide in ratio 9 : 7. Median furrow absent. Clothed with short recumbent hairs.

Eyes: Six. Oval in shape, mounted on black rims. The ocular area is almost as wide as the anterior part of the cephalothorax. A few long bristles are found in front and at the side of the eyes. The median eyes are contiguous and the front and rear laterals are also contiguous. The median eyes are separated from the front laterals by a space equal to about one-third of their long diameter. When viewed from above the median eyes appear to form a straight line with the front laterals. The eyes are subequal in size.

Clypeus: Narrow, the distance from the base of the cheliceræ to the median eyes being about equal to half the long diameter of the eyes. It is clothed with coarse black bristles which project forward.

Fig. 1. *Tasmanoonops alipes*, Hickman.
Left palpus of male viewed from outer side.

Legs: 4, 1, 2, 3. Yellowish brown, clothed with short, finely barbed hairs. A single trichobothrium is present on each metatarsus near the apex and two trichobothria on each tibia, elsewhere none. The tarsal claws are carried on a well-developed onychium. The claws resemble those of

the female, but the wing-like projections on the superior claws are not as large as in the female. The onychium is furnished with spatulate hairs and with five long barbed hairs. The tarsi are short.

Spines: The first and second pairs of legs have no spines. *Third leg.* Femur 0. Patella 0. Tibia-dorsal 0, prolateral 1 - 1 - 1, retrolateral 0, ventral 1 near apex. Metatarsus-dorsal 0, prolateral 1 - 1 - 1, retrolateral 0, ventral 1 in the middle and 1 apical. *Fourth leg.* Femur 0. Patella 0. Tibia-dorsal 0, prolateral 1 - 1 - 1, retrolateral 1 - 1 - 1, ventral 1 - 1 and 2 apical. Metatarsus-dorsal 0, prolateral 2 - 1d - 1v - 2, retrolateral 2 - 1 - 2, ventral 1 and 2 apical. No spines are present on any of the tarsi.

Palpi: The tarsal segment is long and finger-like. Its dorsal surface is thickly clothed with short hairs. The bulb is yellow and nearly spherical. It is attached near the base of the segment and is furnished with a peculiar embolus and conductor. (See Fig. 1.) When viewed from the outer side the embolus appears as a dark coloured serrated projection rising from a chitinous cup, which on one side is produced into a twisted, subtriangular conductor. The wall of the cup is not continuous on the inner side. Near the base of the conductor is found a spine-like projection. The femur, patella, and tibia are short and stout.

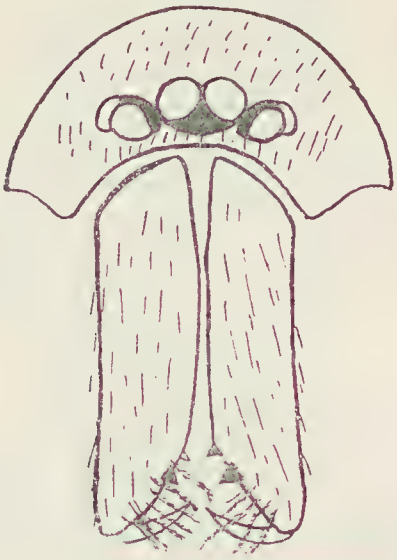


Fig. 2. *Tasmanoonops alipes*, Hickman.
Falces and eyes of male viewed from front.

Cheliceræ: Long, narrow, and parallel, clothed with a few short setæ. Fang well curved. Promargin of furrow armed with a single tooth. Retromargin also armed with one tooth. Long barbed hairs on the promargin as in the female. (See Fig. 2.)

Labium, Maxillæ, and *Sternum* as in the female.

Abdomen: Ovate, grey, marked with numerous faint spots. It is clothed with finely barbed hairs. Two pairs of spiracles are present in the same position as described for the female. One pair leads into book-lungs, the other into tracheæ.

Spinnerets: Six. They resemble those of the female, but the peculiar ventral spines are replaced by short bristles.

Locality: The Great Lake (3,350 feet). 15th March, 1930.

Field Notes: Only one specimen was collected. It was found under a stone near the northern end of the lake.

Genus *Oonopinus*, Simon.

Oonopinus mollipes, sp. nov.

Female. Measurements in millimetres.

Total Length	2.24
Length of Cephalothorax	0.82
Width of Cephalothorax	0.64
Length of Abdomen	1.43
Width of Abdomen	1.00

Leg	Femur	Patella	Tibia	Meta-tarsus	Tarsus	Total
1	0.67	0.25	0.53	0.50	0.36	2.31
2	0.64	0.25	0.53	0.50	0.28	2.20
3	0.43	0.21	0.36	0.39	0.25	1.64
4	0.64	0.25	0.46	0.50	0.25	2.10
Palpi	0.35	0.11	0.14	—	0.25	0.85

Cephalothorax: Dark brown, convex, cephalic part moderately high, not marked with any pattern, but clothed with a few coarsely barbed hairs.

Eyes: Six. The eyegroup is compact and about two-thirds the width of the head. The eyes are of an irregular oval shape. The laterals are equal in size, but the central eyes are longer than and not as wide as the laterals. Front and rear laterals are contiguous. The central eyes are also contiguous with each other, and with the front edge of the

anterior lateral eyes. The space inside the eyegroup is pigmented with black. When viewed from above the central eyes form a slightly procurved row with the front laterals and a strongly recurved row with the rear laterals. (See Fig. 3.)

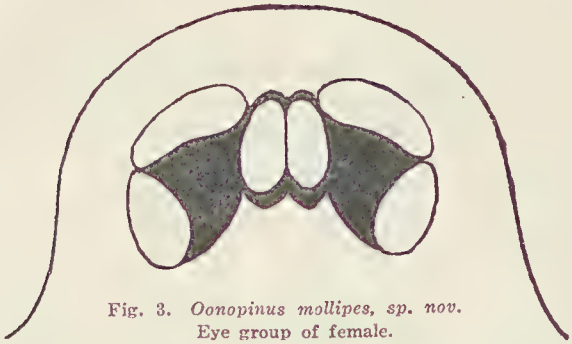


Fig. 3. *Oonopinus mollipes, sp. nov.*
Eye group of female.

Clypeus: Narrow, the distance from the base of the chelicerae to the front edge of the central eyes being about equal to the long diameter of these eyes.

Legs: 1, 2, 4, 3. Brown, clothed with coarsely barbed hairs. Two trichobothria on each tibia and one near the apex of each metatarsus. The tarsi end in an onychium which carries two claws. Each claw has a double row of short, blunt teeth, there being about eight teeth on each side of the claw. The tip of the claw is finely serrated. The hairs on the onychium are not spatulate, but are barbed and different from the hairs covering the other parts of the legs. (See Fig. 4.)

Fig. 4. . *Oonopinus mollipes, sp. nov.*
Tarsal claws of female.

Palpi: Colour and clothing like that of the legs; the tarsal segment is very thickly clothed with barbed hairs. Claw absent.

Spines: No spines are present on either legs or palpi.

Cheliceræ: Brown, conical, clothed with a few hairs like those on the legs. Fang curved and slender. No teeth on margins of furrow.

Maxillæ: Brown, narrow, long, and converging; clothed with a few coarsely barbed hairs. (See Fig. 5.)

Labium: Brown, triangular, its width at the base being equal to its length. (See Fig. 5.)

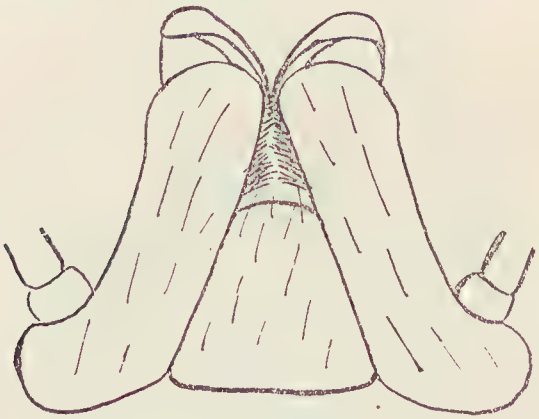


Fig. 5. *Conopinus mollipes, sp. nov.*
Maxillae and labium of female.

Sternum: Brown, shiny, convex, as long as wide; produced between rear coxæ, which are separated by little more than their diameter. The middle area of sternum is smooth and devoid of hairs, but round the margin it is clothed with coarsely barbed hairs. First coxæ wide apart. In outline the sternum is cordiform.

Abdomen: Ovate, brownish grey above, the rear half being marked with a longitudinal patch of lighter colour. The ventral surface light fawn. Two pairs of spiracles. The anterior pair are placed one on each side of the body in front of the epigastric furrow and open into book-lungs. The posterior pair are immediately in rear of the furrow and somewhat nearer the central line. They open into tracheæ.

Spinnerets: Six. The anterior pair larger than the others.

Locality: Trevallyn, Launceston. 27th May, 1930.

Field Notes: Collected in grass tussocks. Three female specimens were found.

Genus *Orchestina*, Simon.

Orchestina launcestoniensis, sp. nov.

Male. Measurements in millimetres.

Total Length	1.22
Length of Cephalothorax	0.58
Width of Cephalothorax	0.43
Length of Abdomen	0.73
Width of Abdomen	0.58

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
1	0.51	0.15	0.47	0.36	0.24	1.73
2	0.51	0.15	0.48	0.44	0.24	1.82
3	0.35	0.14	0.28	0.32	0.21	1.30
4	0.53	0.15	0.37	0.44	0.24	1.73
Palpi	0.17	0.07	0.22	—	0.17	0.63

Cephalothorax: Yellowish brown, marked with regular dark brown lines as in the female. (See Fig. 6.) Convex, the highest point being between the third coxæ. From here it slopes gradually to the front and somewhat more steeply to the rear. Sides rounded and margined with dark brown. A few long erect hairs are scattered over the surface.

Eyes: Six. The lateral eyes are equal in size and contiguous. The median eyes are oval in shape, contiguous, and larger than the lateral eyes in ratio 5 : 4. They are separated from the anterior lateral eyes by a space equal to one-fifth of their own long diameter. When viewed from above the median eyes and the anterior laterals form a slightly recurved row. All the eyes are pearly white and mounted on black rims. (See Fig. 6.)

Clypeus: Height slightly less than the long diameter of a median eye. Clothed with a few long coarse hairs.

Legs: 2, 1, 4, 3. Yellowish brown, clothed with long finely barbed hairs. A single trichobothrium at the apex of each metatarsus and two trichobothria on each tibia. Rear femora very much dilated. Tarsi provided with an onychium which carries two claws. In microscopic preparations each claw is seen to be provided with two rows of teeth. The outer row consisting of five or six teeth, which increase in size towards the base of the claw and the inner row consisting of two or three small teeth.

Palpi: Bulb large and pyriform. Tibial segment strongly dilated. The long sperm duct may be clearly seen inside

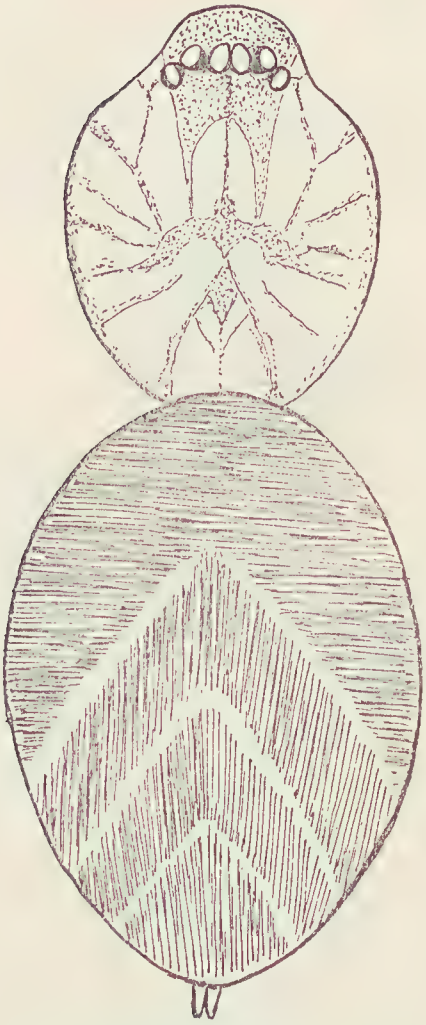


Fig. 6. *Orchestina launcestoniensis, sp. nov.*
Cephalothorax and abdomen of female.

the bulb. It forms a spiral consisting of two complete turns and two half turns near the base of the bulb. The embolus is short, curved, and black. The tarsal segment is spoon-shaped. Its length is shorter than the width of the bulb in ratio 4 : 5. (See Fig. 7.)

Spines: There are three spines at the apex of the fourth metatarsi. Elsewhere none.

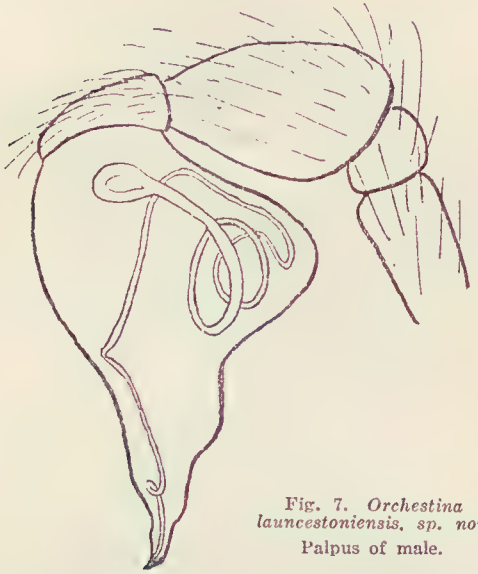


Fig. 7. *Orchestina launcestoniensis, sp. nov.*
Palpus of male.

Cheliceræ: Slender and conical. Fang strong and well curved. Margins of furrow not armed with teeth, but the inner surface of the paturon is studded with minute conical spines. A light scopula of barbed hairs on promargin of furrow. (See Fig. 8.)

Fig. 8. *Orchestina launcestoniensis, sp. nov.* ♀
Chelicera showing minute teeth on inner surface of paturon.

Maxillæ: Inclined over labium. The apical quarter is divided into two lobes. When the mouth parts are carefully dissected it is found that one lobe is pale yellow and carries a light scopula of finely barbed hairs. The other lobe is ventral to the former and has the shape of a narrow, dark brown projection, which points forward. It carries a well-developed serrula and ends in a slightly curved tip. (See Fig. 9.)

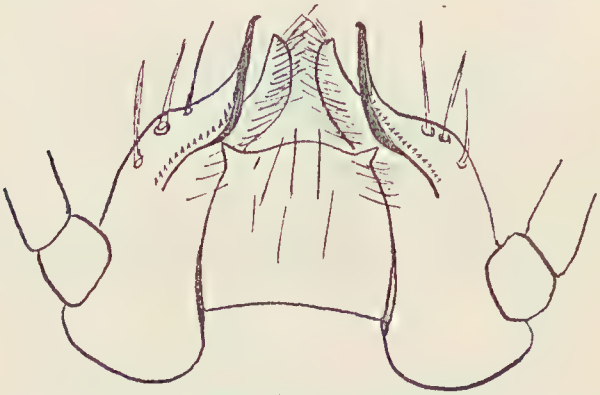


Fig. 9. *Orchestina launcestoniensis, sp. nov.*
Labium and maxillae of male.

Labium: Rounded in front and at the sides. The front margin produced into a point on each side. This point appears to fit between the two apical lobes of the maxilla. (See Fig. 9.)

Sternum: Yellowish, moderately convex, cordiform; separated by a deep groove from the labium and produced between the rear coxæ.

Abdomen: Ovate. Dark brown above, fawn underneath. Dorsal surface is marked with three chevrons as in the female. (See Fig. 6.) The area in front of the anterior chevron is finely striated with dark transverse lines. The area in rear is marked with fine longitudinal lines. The clothing consists of long hairs mingled with short hairs. Two pairs of spiracles as in female.

Spinnerets: Six. Anterior pair larger than the others. Middle pair very slender.

Female. Measurements in millimetres.

Total Length	1.33
Length of Cephalothorax	0.64
Width of Cephalothorax	0.46
Length of Abdomen	0.75
Width of Abdomen	0.64

Leg	Femur	Patella	Tibia	Meta-tarsus	Tarsus	Total
1	0.49	0.17	0.43	0.40	0.22	1.71
2	0.49	0.17	0.43	0.43	0.22	1.74
3	0.37	0.15	0.28	0.30	0.18	1.28
4	0.56	0.18	0.29	0.44	0.19	1.66
Palpi	0.17	0.08	0.12	—	0.17	0.54

Cephalothorax: Ovate, convex, highest point between the third coxæ. Marked with a regular pattern of dark lines on a yellowish brown ground. Margin with a brown edge. Surface clothed with a few long erect hairs. (See Fig. 6.)

Eyes: Six. Mounted on black rims. Oval in shape. Median eyes separated from the front laterals by one-third of their own diameter. The lateral eyes are equal in size and contiguous. The median eyes are also contiguous and slightly larger than the laterals in ratio 6 : 5. The front laterals and the median eyes form a slightly recurved row, when viewed from above.

Clypeus: Clothed with a few long hairs. Its height is equal to two-thirds of the long diameter of a median eye.

Legs: 2, 1, 4, 3. Yellowish brown, clothed with finely barbed hairs. A single trichobothrium near the apex of each metatarsus and two on each tibia; elsewhere, none. Rear femora dilated. Tarsi end in an onychium. Two tarsal claws are present. Each claw has a double row of teeth, three small teeth on the inner side and seven larger teeth, which increase in size towards the base, on the outer side. (See Fig. 10.)

Fig. 10. *Orchestina launcestoniensis, sp. nov.* ♀
Tarsal claws, showing teeth on outer side.

Spines: Absent from all the legs.

Cheliceræ: Conical and slightly stronger than those of the male. Fang well curved. Margins of furrow without

teeth. The inner surface of the paturon armed with minute conical spines. A light scopula of barbed hairs on promargin of furrow. (See Fig. 8.)

Maxillæ: Narrow, converging over labium. Apical portion normal and not divided into two lobes as in the male. Provided with a light scopula of barbed hairs on inner side. Serrula present on outer side. (See Fig. 11.)

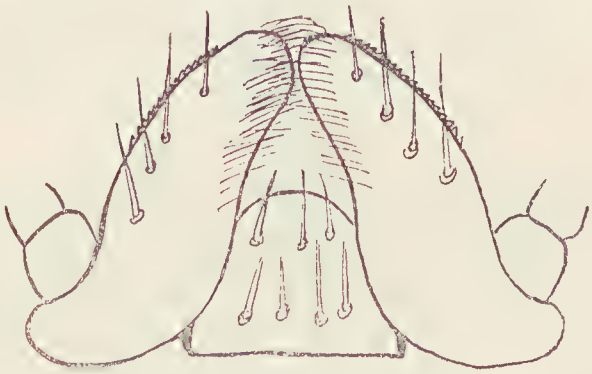


Fig. 11. *Orchestina launcestoniensis, sp. nov.*
Labium and maxillae of female.

Labium: Rounded in front and at the sides. Not produced into a conical point on each side of front margin. Its sides are slightly overlapped by the maxillæ, making it difficult to see without dissecting the mouth parts.

Sternum: As in the male.

Abdomen: Ovate, brownish above, fawn underneath. The dorsal surface is marked with three chevrons and striated as in the male. (See Fig. 6.) Two pairs of spiracles are present. The anterior pair are placed one on each side immediately in front of the ends of the epigastric furrow. The posterior pair are close behind the furrow and a little nearer the middle line.

Spinnerets: As in the male.

Locality: Punch Bowl, Launceston. 24th May, 1930.

Field Notes: This little spider is very common in grass tussocks. When touched, it jumps backward. This habit is no doubt correlated with the strong development of the femora of the fourth pair of legs.

Types: In the Queen Victoria Museum, Launceston.

NOTES ON THE FOSSIL SPORES IN AN OIL-SHALE FROM TASMANIA.

By

T. C. N. Singh,

Formerly Lecturer in Botany at the University of Lucknow.

(Communicated by P. B. Nye, M.Sc., B.M.E.)

Plate IX. and Three Text-figures.

(Read 13th July, 1931.)

Tasmanite is an oil-shale known to occur in the Permo-carboniferous (1) of the North and North-Western districts of Tasmania. The shale is of sedimentary origin and is brownish grey in colour, being largely impregnated with spores which have been named by Newton as *Tasmanites punctatus* Newt. (2). On distillation the shale yields an artificial petroleum which is claimed to be obtained from these spores (3). Thus it is chiefly for its economic importance rather than palæo-botanical that it has been engaging the attention of investigators from time to time.

During the course of an examination of these spores, few points have come to notice which deserve mention.

As stated above, the shale is mainly composed of spores. They appear—even with the naked eye—as flattened circular dot-like bodies, thousands of them sticking to the fine-grained arenaceous matrix. When a small piece of the shale is gently crushed and stirred under water in a ptre-dish, the spores, being lighter, separate off from the heavy sandy particles. On treatment with *Diaphanol* they become somewhat bleached and show the structure more clearly. They, however, are rather averse to taking up stains except for a little of Safranin.

When not damaged the spores are circular and are of varying size (fig. 1)—200 μ to 533 μ in diameter (4). The

(1) McIntosh Reid, A. (1926), p. 43.

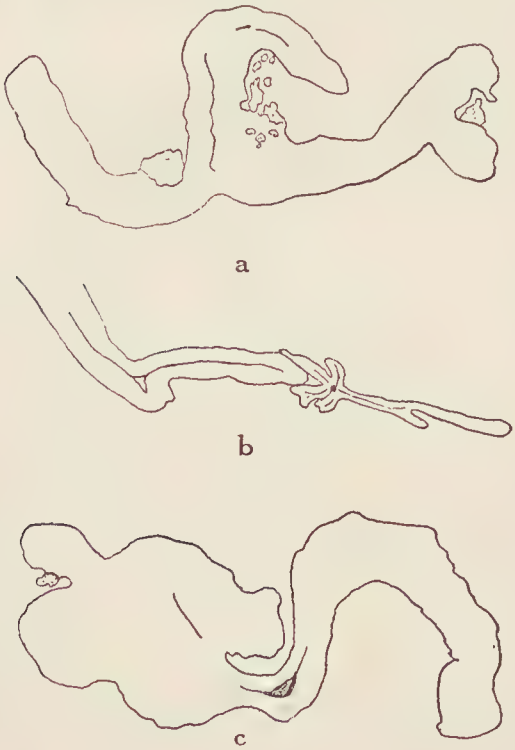
(2) Newton, E. T. (1875), p. 341.

(3) McIntosh Reid, A. (1924), pp. 35-37.

(4) Measurements of a dozen and a half representative spores taken at random, are as follows:—200μ x 283μ; 233μ x 233μ; 250μ x 275μ; 266μ x 233μ; 283μ x 316μ; 291μ x 308μ; 316μ x 333μ; 333μ x 350μ; 333μ x 366μ; 358μ x 333μ; 366μ x 450μ; 400μ x 433μ; 416μ x 425μ; 433μ x 450μ; 450μ x 466μ; 466μ x 500μ; 500μ x 500μ; 500μ x 533μ.

punctated surface to which Newton alludes (5), is not at all seen in any of my slides, instead, in favourable cases characteristic surface-sculpturings have been observed (figs. 2. 4, 5, 7, and 8). In others these surface-sculpturings seem to have been rubbed off during fossilisation. In certain spores distinct tri-radiate marks (fig. 3) are clearly visible.

Serial microtome sections (6) (figs. 10-12 and text-figs. a-c) were cut with a view to seeing the presence of cell-contents, but the result has so far turned out to be negative. However, one thing is plainly evident, namely that the spores appear to have been pressed hard during fossilisation in



Text-figures a-c. (Camera-lucida sketches.) Microtome sections of spores, showing peculiar shapes. (The dotted shading represents the sand-particles.)

(5) Newton, E. T. (1875), p. 341.

(6) Sections as thin as 6μ have been microtomed with ease. The process is dehydration, etc., is exactly similar as employed in usual micro-technique.

various planes, and have thus been reduced to thin strips, which show slight stratification. Not unoften, the spores ruptured only on one side may be met with (fig. 6). The shape of the spores is determined by the planes of the strata abutting on them, such that they present often very peculiar shapes in section (fig. 12 and text-figs. a-c).

DISCUSSION.

These spores have variously been regarded by different (7) authors as resin, marine deposit, algæ of spherical form, spores, and sporangia. The present observations, however, lend support to the last view. The demonstration of a triradiate mark and surface-sculpturings removes the suspicion of the algal nature of the spores.

Newton, supported by others, has made a suggestion that "their (spores) form and size seem to indicate that they are "more nearly allied to Lycopdiaceous macrospores than any-"thing else" (8). An experiment performed in this connection by Stewart (9) is rather significant. He, on distillation of a mixture of 25 per cent. of Lycopodium powder and 75 per cent. of fuller's earth was able to condense a substance similar to the shale-oil obtained from the *Tasmanite*. But an examination of the surface characters of the spores of the living Lycopods (10) does not show any identity with those of *Tasmanites punctatus*. At the same time, it is rather curious that no fossil Lycopods, or even their allies, have so far been recorded near about the same horizon from Tasmania (11). The only members from the same strata as the oil-shale, are either Gymnosperms or one of the Equisetales—*Phyllotheca australis* Brong. (11). With such incomplete data before us, it is rather unsafe to relate these spores to one or the other until some positive evidence is forthcoming.

Considerable variation in the size of spores has suggested some authors to think that they include a mixture of both micro- and macro-spores, but this does not seem to be tenable, because even the smallest spores are rather too big to be regarded as microspores as compared with the bigger ones, and besides this nothing of the like is known in any other fossil plant so far. There may, however, be another possibility, namely, that they are derived from closely

(7) Twelvetrees, W. H. (1911), Bull. 11.

(8) Newton, E. T. (1875), p. 341.

(9) Stewart, D. R. (1912), pp. 164-5.

(10) I am thankful to Prof. M. O. P. Iyengar, of Madras, who was kind enough to send me spores of certain living Lycopods. This helped me a good deal in making comparisons.

(11) Sahni, B. (1926), p. 325.

related species of plants. If this is true, then more than half-a-dozen species may be involved. Nevertheless, the shape and structure of the spores are so very similar that they suggest being derived from a single species. This variation in size seems to be due to a mixture of mature and immature spores. Such a polymorphic phenomenon is quite common among vascular plants (12).

SUMMARY.

An examination of the fossil spores present in *Tasmanite* has been made, and the following results have been obtained:—

(1) The surface of the spores is not punctated (in my specimen) as stated by Newton, but instead has definite sculpturings.
(2) Tri-radiate mark on the spores is present in favourable cases.
(3) These spores have been microtomed for the first time.
(4) The spore-wall in section often shows slight stratification.
(5) These spores are averse to taking up any stain except a little of safranin.
(6) The suggestion of their Lycopod-origin is doubted.
(7) Variation in the size of spores is due perhaps to the mature and immature spores being mixed together.

ACKNOWLEDGMENTS.

I have great pleasure in recording my sincere thanks to Dr. Pascoe, Director of the Geological Survey of India, for having allowed me the use of reference books kindly sent out to me from the library of the Geological Survey; to Mr. A. McIntosh Reid, Director of Mines, Tasmania, for the specimen which he kindly sent me at my request in December of 1927.

BHOWALI (Nainital Hills),
Oct. 9th, 1930.

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(12) Bower, F. O. (1923), pp. 263-4.
Singh, T. C. N. (1929), p. 207.
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EXPLANATION OF THE PLATE.

(All are camera-lucida sketches, and the shaded area in the figures denotes the sand-particles yet sticking to the spores.)

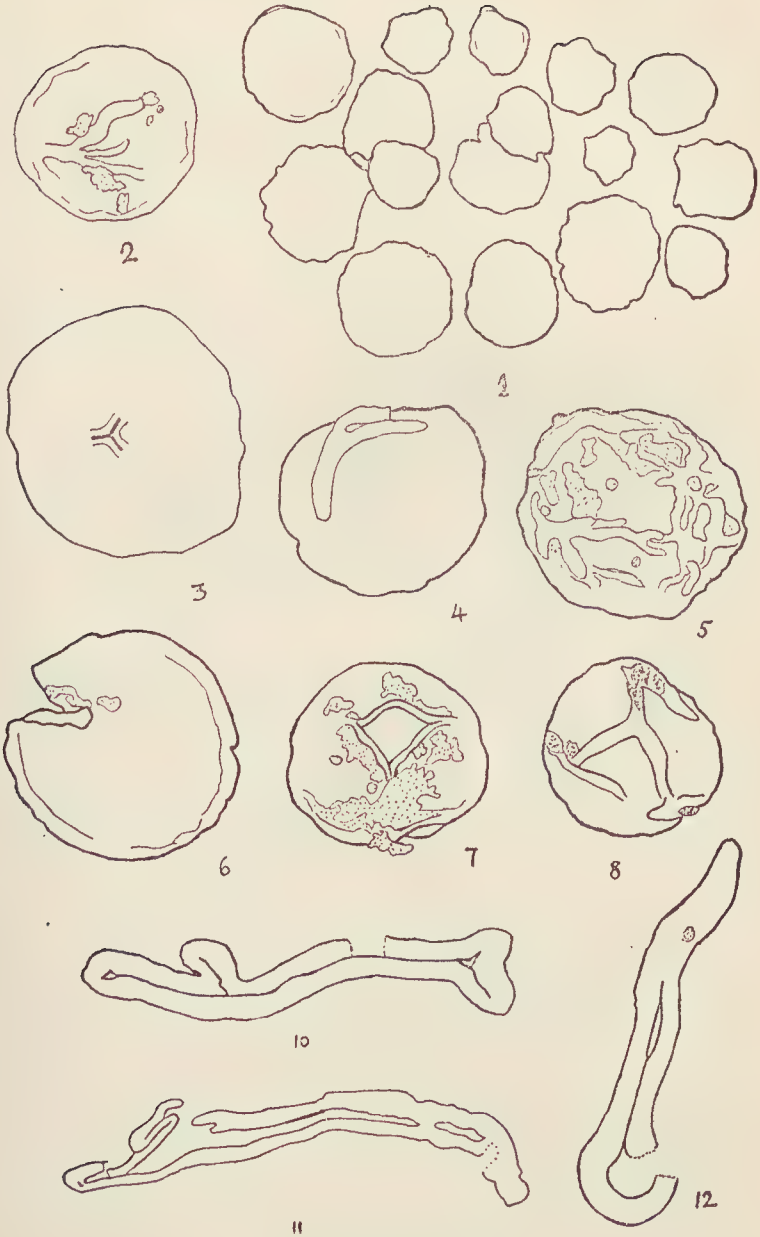
Fig. 1. - Spores of various sizes. X 44.

Figs. 2, 4, 5, 7, 8. Spores with surface sculpturings, fig. 5 being typical. Figs. 2 & 7 — X 102; Figs. 4-5 — X 92; Fig. 9 — X 126.

Fig. 3. A spore with a distinct tri-radiate mark. X 100.

Fig. 6. A spore ruptured on a side, showing the mouth-like fold. X 102.

Figs. 9-11. Microtome sections of spores. X 203.



Tasmanites punctatus.

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ON THE STRUCTURE OF THE RESPIRATORY ORGANS OF THE TERRESTRIAL ISOPODA.

By
Ernest E. Unwin.

Plates X.-XVII.

(Read 13th July, 1931.)

1. INTRODUCTION.

Terrestrial isopods present problems in respiration because of their change of habitat. With organs of respiration which are homologous with the branchiæ of *Asellus* and other aquatic isopods, they live on land and breathe air. They are found in very varied situations; some require very wet conditions, others can live in comparatively dry places.

In this communication I propose to describe the interesting anatomical features of the respiratory organs of certain species.

In the species treated of, and in the *Oniscoidea* generally, five pairs of abdominal appendages take some part in respiration. I propose to describe these appendages in the female forms only. There are no differences in the essential points of histology and physiology between the male and female pleopods, and the fact that, in the male, reproductive processes are associated with the 1st and 2nd pleopods, brings in an unnecessary complication.

Methods.

Living Specimens: I have indicated the methods in use for examining the abdominal appendages *in situ*.

Abdominal appendages as flat objects: Methylene blue, as a stain for living tissue, as well as for fixed ones, is most useful. Prussian blue gelatine injection has been used to investigate the limits of blood cavities.

Paraffin serial sections: For fixing I have found Flemming's solution the best. Hot 80 per cent. alcohol has given good results with some.

Staining: Delafield's hæmatoxylin followed by eosin in 90 per cent. alcohol. The staining has been done on the slide in dipping jars.

II. SPECIES DEALT WITH.

1. *Trichoniscus pusillus*, Br.

Pl. X., figs. 1-6.

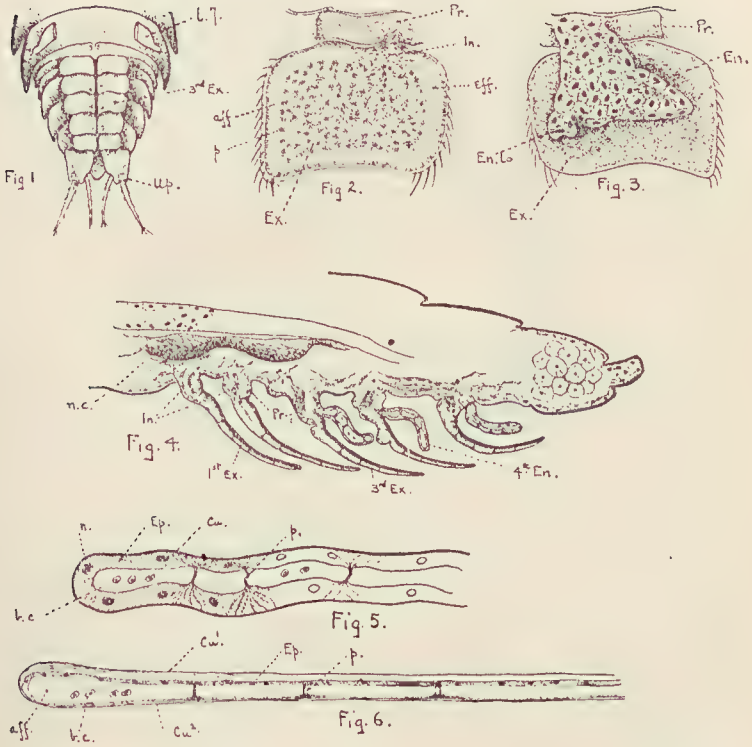
The ventral surface of the abdomen is shown in Fig. 1. It is covered by five pairs of oval plates, which overlap from before backwards, and those of either side meeting together in the mid-ventral line.

Normally each of these plates indicates an abdominal appendage, consisting of a basal part, an outer plate (exopodite) and an inner plate (endopodite), but the endopodites are missing from the first two pairs of appendages. Thus there are five pairs of exopodites and three pairs of endopodites. These are the respiratory organs.

In many forms the structure of all the exopodites is similar and the same applies to the endopodites; it will be convenient, therefore, to take the 3rd abdominal appendage for special study as this is the first complete appendage. Where differences exist between the exopodites of the 1st and 2nd abdominal appendages and that of the 3rd, the description will be extended to include them.

Figs. 2 and 3 show the 3rd abdominal appendage seen from the ventral or outer, and from the dorsal or inner aspect. The exopodite acts as an operculum for its rather smaller and more delicate endopodite. Each plate takes part in respiration. This has been made clear by observation, by experiment, and by the evidence afforded by sections. If a living specimen is observed under a low power of the microscope, the abdominal appendages seem covered with a film of water, at least the endopodites are, for as the exopodites are raised and lowered—an action which, although not absolutely regular, is fairly continuous when the creature is not moving and which is a breathing action—a film of water retreats and advances under the free edges of the exopodites. This shows that the endopodites are kept very wet and are used for respiration in a very damp condition. By using a higher power the circulation of blood can be observed in the exopodites. They are well supplied with blood, and act as additional breathing organs. I proved this by putting the endopodites out of action, in this and in other woodlice, by inserting some vaseline under the exopodites. The creatures lived for very considerable periods. In the control experi-

TRICHONISCUS PUSILLUS ♀.



Trichoniscus pusillus ♀.

NATIONAL MUSEUM

ment with the whole of the ventral surface of the abdomen made impervious, the woodlice did not live more than two days at the longest.

It is also clear from the transverse sections that the exopodites are used as organs for respiration, and that the outer or ventral surfaces function to this end. The chitinous cuticle of the ventral or outer wall—the wall towards the air, the oxygen medium—is very thin and the inner or dorsal wall quite thick. If the exopodite functioned as an operculum solely, the outer or ventral wall would be the thicker, as it is for instance in the 3rd abdominal exopodite of *Asellus*. This will be referred to below when the transverse sections are described in detail.

We shall find as we study the woodlice adapted for drier situations, that the exopodites become more and more important as breathing organs. It is in the exopodites that accessory breathing organs are developed; and the endopodites, although three pairs are always present, become less important in consequence.

The Exopodite: The exopodite is roughly oval in outline. (Fig. 2.) When seen under the microscope as a transparent object, either in the fresh living condition or treated with methylene blue, the surface is covered with small dots, which are not arranged evenly over the surface. These dots are the nuclei of the epithelial layer, and here and there where they are grouped together comes an inter-lamellar pillar or bridge (le pilier of Kimus (1)). The space between the two walls traversed by these pillars is the blood cavity. There are no definite blood vessels, but at the sides of the appendage channels can be seen, free from pillars. These are the inhalent and exhalent blood channels, or afferent and efferent canals. It has already been noted that the circulation of the blood can be seen. This is due to the large size of the blood corpuscles. The blood collects into a large ventral sinus in the abdomen and is drawn through the abdominal plates by the pumping action of the heart, which, receiving purified blood, propels it forward to the head and to the body generally. The blood enters the exopodite at the point of attachment, and runs along the inner border in what we may call the afferent canal, finds its way between the two lamellæ, into the efferent canal along the outer border, and so out of the appendage. The blood is prevented from short circuiting from the afferent to the efferent in

(1) Kimus (see Bibliography).

the proximal part of the exopodite by the presence of a tissue which is continuous with and similar to the tissue found in the body cavity. This is the intermediary tissue to use the name suggested by Kimus (le tissu intermediaire).

If the exopodite be examined by transverse or longitudinal section (Figs. 4 and 6), the details of the two walls or lamellæ can be seen. Each lamella consists of an epithelial part and a cuticle, and the two lamellæ are very different. The inner or dorsal wall has a fairly thick cuticle, and the epithelial lining is quite distinct with its nuclei at frequent intervals. This epithelial lining is a single layer of cells which give rise to the cuticle on its outer face. The cuticle of the outer or ventral wall (or lamella) is very thin, and the epithelial lining is also extremely thin, indeed in most sections it is not seen except in the region of the pillars, but at the time of the formation of a new cuticle the layer is distinctly seen. In a later communication I have described and figured a section through an exopodite at the time when this layer shows best of all (Pl. XIII., fig. 28). Sometimes the very thin remains of the layer is seen when by some action (osmosis) the protoplasmic lining becomes distorted. The pillars pass from cuticle to cuticle. The outer wall of the exopodite is thus adapted for respiration through its very thin wall; the inner wall for protection and for the necessary support of the exopodite itself (Fig. 6).

Stoller (2), to whose work upon the breathing organs of woodlice I shall have occasion to refer and to correct in many important particulars, does not describe *Trichoniscus*, but refers very briefly to *Ligidium hypnorum*. He says, referring to a cross section of the exopodite of which he gives a figure:

"It is seen that the gill (= exopodite) is in principle a ' simple sac containing blood. The outer layer of the wall, " composed of chitine, is much thicker on the ventral than " on the dorsal side of the gill. The hypoderm (= " epithelium) everywhere lines the chitine, and in general " varies with it in thickness."

This is the exact opposite of what I find in *Trichoniscus*, and at first I thought that this section of *Ligidium* must have become turned round in some way, or that we were using the terms "dorsal and ventral" in different ways, but a few lines further on he makes it quite clear that he looks upon the inner surface (that is the dorsal surface as the plates are found *in situ*) as the respiratory one, and that it is in

(2) Stoller (see Bibliography).

use when the air enters the space in which the endopodite lies. By the following extract it is clear that he imagines only one kind of respiration—that taking place in the endopodite cavity, whereas the outer surface of the exopodite is adapted for respiration of a different kind. (See Summary.)

"It is true that as the blood circulates through the gill, "it is separated from the external atmosphere by the rather "thick ventral wall of chitine. But through the movements "of the gill, taking place as described for *Porcellio*, air is "constantly brought into relation with the inner surface "where the chitinous wall is thin." (Stoller.)

It will be best to correct at once this serious mistake in Stoller's account, for it occurs in his descriptions of other species. In his description of the last three pairs of exopodites of *Porcellio scaber*, which are more or less normal in structure and do not possess the air-tree organs, he describes their function as protective covers for the endopodites and their movement causing renewal of air to the endopodites. I agree in these two functions, but do not agree with the observation given below as to the structure of the wall.

"It is possible that the outer gills (= exopodites) in "addition to performing these functions, contitute in themselves organs of respiration. The blood circulates between "the two walls of the gills, and whether respiration takes "place depends upon the penetrability of the walls to the "gases to be exchanged. The *ventral wall of chitine is* "*thick*—thicker than the chitinous wall in some other regions "of the body as, for example, the thoracic legs (in which also "the blood circulates). The dorsal wall is, on the other "hand, *moderately thin*. It is, moreover, exposed to the "moist air in the chamber in which the inner gills lie. It "would seem probable, therefore, that to some extent "respiration may take place *through the dorsal wall*." (Stoller.)

This extract goes to show that in Stoller's mind the dorsal wall, the one that is applied to the endopodite, is considered thinner than the ventral wall, the one that is bathed by the external air. I have examined all the common species of woodlice and find the opposite arrangement in every case (except where a great change like the development of an air-tree organ has altered the exopodite). In *Ligia oceanica, Trichoniscus pusillus and roseus, Oniscus asellus, Philoscia muscorum and conchii, Porcellio scaber,*

Cylisticus convexus, *Armadillidium vulgare*, *Porcellionides pruinosus*, *Platyarthrus hoffmannseggii*, the ventral wall is the thinner, and is normally adapted for respiration. We shall see that some species use this ventral surface more than others, but there is not the slightest doubt but that Stoller is incorrect in his description. A glance at Figs, 4, 25, 53, 57, 59, and 69 will show this.

The Endopodite: It has already been pointed out that there are only three pairs of endopodites. The 3rd abdominal exopodite is the first to have a corresponding endopodite. This latter is slightly smaller in area than its exopodite, but its structure is in marked contrast, as can be seen in figures 3, 4, and 5. The chitinous cuticle is very thin, and the epithelium is, on the contrary, very thick, and the whole appendage is spongy. There is one peculiarity which I have not noticed in the endopodite of any other woodlouse, and that is a lobe which is seen attached to the inner distal corner of the appendage. The blood cavity of the endopodite is continuous with that of this lobe. In Fig. 3 I have attempted to show the nuclei and the large epithelial cells as they are seen after the endopodite has been treated with methylene blue. In Fig. 5 a portion of an endopodite is shown as seen in cross section. The large nuclei are very clear, but the cell boundaries cannot be seen. There are very few pillars running from the epithelium of one wall to that of the other. They are narrow pillars, and as one follows them into the epithelium radiating fibres can be seen. The blood cavity is very variable in size, in some sections the epithelial linings are closely opposed, in others they are widely separated. These observations support Kimus's suggestion that the function of the pillars is partly to assist the flow of blood through the appendages.

The pillars are very similar to the type found in the endopodites of *Asellus aquaticus*, and to which Kimus has devoted so much attention. The chief point to note here is that these pillars are not complete cells, but formed of the fused protuberances which are carried by the large epithelial cells. Kimus in summarising the kinds of pillars found says of this kind—

"Enfin, le pilier formé par l'union, à travers la cavité "branchiale, de protubérances appartenant à deux larges "cellules épithéliales, qui en possédent plusieurs semblables."

The pillars of the exopodite are quite different. They are formed of the union of two or more cells. The cells of

one wall unite with the cells of the opposite wall. The question of these pillars is discussed in the summary.

2. *Oniscus asellus*, Linn.

Pl. XI., figs. 7-16.

The general arrangement and number of the abdominal appendages are the same as in *Trichoniscus pusillus*. Looking at these appendages *in situ*, a peculiar feature is at once seen. The outer border of each exopodite has quite a different appearance from the rest of the exopodite. This outer border appears as a silvery white segment, rather less than a semi-circle in shape and occupying from one-fifth to a quarter of the area of the whole exopodite. (Pl. XI., fig. 7.) This unusual appearance attracted my notice, and I began to study it by observations on living specimens and by means of sections. When watching the breathing action of *Oniscus* under a low power of the microscope, it was clear that these border organs had bubbles of air underneath them, and that the silvery appearance was due to this. With a little patience one could get the air replaced by water, and then the silvery appearance disappeared. By flooding the *Oniscus* with weak alcohol, the air was dislodged, and the alcohol could be replaced by water before any permanent injury was done. In this way I satisfied myself that the silvery appearance was entirely due to the air imprisoned under the corrugated crescentic lobes. I mention this here because below I shall refer to Stoller's work which later caused me to review the whole matter.

This special part is very thin and, having its outer or ventral wall flush with that of the ordinary part, there is a considerable space between its inner or dorsal wall, and the underlying exopodite or the body wall. This is the air or lung cavity, and the air is renewed by the raising and lowering of the exopodites as well as by the flexing of the abdomen and other movements caused by locomotion.

Besides this special arrangement, designed, as we shall see, for more efficient respiration of air, *Oniscus* has exopodites and endopodites which, similar to those already described in *Trichoniscus*, are adapted for breathing of moist air. The endopodites, although not so wet as those of *Trichoniscus*, are yet obviously meant for the same kind of respiration, and the habitat confirms this conclusion: for *Oniscus* is often found along with *Trichoniscus* in very damp situations; but the presence of other breathing organs en-

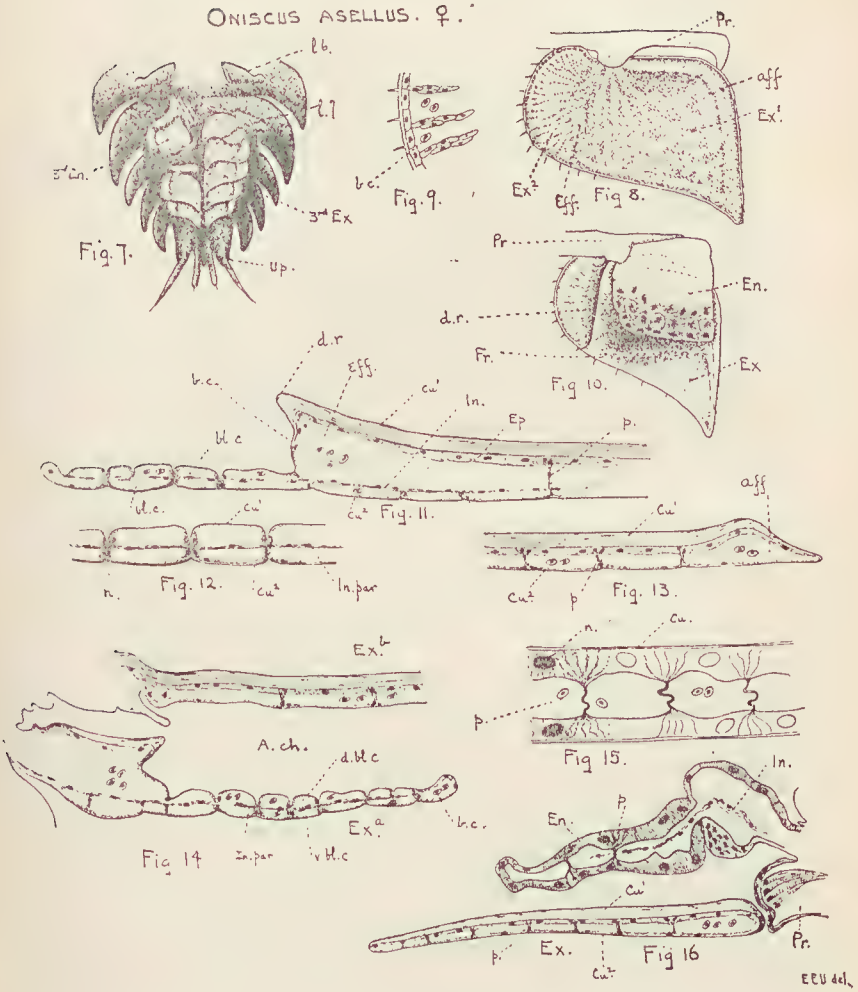
ables it to exist in places which would be too dry for *Trichoniscus*. I shall refer to this in detail later.

The 3rd Abdominal Appendage: Fig. 8 gives a general view of the appendage from the ventral side, and in Fig. 7 the 3rd exopodite on the right side has been turned back to show its corresponding endopodite. Reference to these drawings will save much description. The ordinary part of the exopodite and the endopodite exhibit much the same structure as these appendages in *Trichoniscus*, although the larger size makes it easier to examine the histology in detail. Reference to Figs. 11, 15, 16, especially to Fig. 16, which is a longitudinal section passing through an exopodite and its endopodite in such a way as to pass through the ordinary part of the exopodite, will show the chief points of interest.

The Exopodite: In the main part of this plate the inner or dorsal wall has a very thick cuticle, carrying still further the arrangement we have noted in *Trichoniscus*, and to which we have already referred at some length. The outer or ventral wall is very thin, and points to the use of the outer face of the exopodite as a valuable breathing organ, for not only is the chitinous cuticle very thin, but the epithelial layer is also very much reduced, so much so that in places it is difficult to make out. Thus the blood which flows through the appendage is brought into close relationship with the air outside, and the necessary interchange is possible.

The pillars are more frequent here than in *Trichoniscus*. They resemble the simpler pillars found in *Asellus*, described by Kimus in his memoir. At the base of the appendage the third tissue, the intermediary tissue, can be seen, pushing a little way into the appendage acting as a partition to direct the flow of blood and to prevent the blood staying in the proximal part of the appendage. This tissue, consisting of elongated stringy cells with prominent nuclei, is seen in sections, and can also be seen in the appendage after treatment with methylene blue, and examined as a flat object. In the special part of the exopodite, this tissue becomes a very thin threadlike partition, sometimes double, continuous with a similar partition in the proximal part of the appendage, especially in the part abutting on the special part. This partition serves to divide the internal blood cavity into an upper and a lower cavity.

The structure of this special part of the exopodite must be dealt with in some detail, for it is here that I find myself in serious disagreement with Stoller. After reading his



Oniscus asellus ♀.

account I repeated my own experiments and sectionised the appendages again, and also tried the experiments suggested by Stoller. I will first of all give a detailed description of this part as it is seen by me, and then give Stoller's view, pointing out where I think he is in error.

The figures make clear the general structure. We notice that the exopodite as it approached the outer border where this special segment is situated becomes very much thicker, and then suddenly narrows to less than one-third its thickness; the dorsal wall is the one that alters, the ventral wall of the special part and that of the rest of the exopodite are flush with one another. Besides the change in levels the inner or dorsal wall changes in the thickness of the chitinous cuticle. In the ordinary part of the exopodite it is very thick, in the special part it is exceedingly thin, the thinnest cuticle found anywhere in these appendages. The outer or ventral layer of cuticle is very thin, but decidedly thicker than this on the inner surface of the special part. This points to the fact that the inner surface is of more importance from a respiratory point of view. Both surfaces are thrown into corrugations, but these are much deeper on the inner surface.

Turning now to the internal structure. In all sections, transverse or longitudinal, a partition is seen running through about mid-way between the two faces, but the deeper corrugations of the inner or dorsal surface make the cavities on that side rather larger.

This partition consists of elongated threadlike cells with elongated nuclei. The partition in some places is double with a very narrow space between the two threads, but in other places it appears as a single partition. This partition, the intermediary tissue, is continued into the ordinary part of the exopodite for a greater or lesser distance. Near the proximal portion of the exopodite this partition can be traced into the protopodite, but in the distal part it can be traced but a short way.

The internal cavities are interrupted by the pillars which pass from one face to the other. It is usually only at the base of these pillar cells that any trace of the epithelial lining can be made out. This lining is extremely thin. The pillars are of a somewhat different nature here in that they are grouped together into bands. This arrangement, together with the intermediary tissue, divides the cavity into two sets of radial passages, one set of passages on each side of the partition. This can be seen in a surface view, and an

attempt to show the radial arrangement of pillars is seen in Figs. 8 and 9. If a living specimen is examined under a low power, it is easy to observe the course of the blood flowing through these radial passages. The blood enters the appendage at its place of articulation, which is near the outer border. The blood stream divides, some of the blood going to the exopodite in the ordinary way passing down the afferent canal along the inner border and working its way across the appendage into the efferent canal, which is the boundary between the two parts of the exopodite, and, by this, out of the appendage: other blood takes a different course, it goes to the special part. The transparent character of this special part makes it comparatively easy to observe the circulation. It is best to remove the last pair of legs, and then invert the creature in a watchglass of water, and rest a cover glass on the creature to restrain its movements. The blood corpuscles travel through the ventral radial passages (the uppermost ones, as the animal is placed) towards the margin of the special part. The partition is so transparent that it is not visible, but its presence is obvious, for as the corpuscles get to the margin they suddenly fall through, as it were, to the lower chamber, and one can see them travel back, slightly out of focus, in the dorsal radial passages. The partition comes to an end just before the margin is reached, which accounts for the observation above. Thus in *Oniscus* we have, besides the main portion of each exopodite, which is similar in function to the exopodites of *Trichoniscus* with its outer or ventral surface adapted for respiration, a set of special breathing organs developed on the outer border of each exopodite. Enough has been said to show that these are most valuable additions to the respiratory powers of this creature. The blood in the passages is only separated from the air outside by the thinnest of walls, and the constant supply of blood and the repeated change of air supply the requisite conditions for an efficient breathing organ.

The account given above differs in several important points from that furnished by Stoller. It will be best to quote from his treatise the paragraphs with which I am in disagreement.

P. 25—" . . . In *Oniscus* the general cavity of the gill× " is not a simple cavity as in *Porcellio*, but is separated into " a number of chambers by means of partitions lying parallel " to the walls of the gill.

(×Gill or outer gill is used for exopodite; inner gill for endopodite.)

"In the general part of the gill there are two of these "chambers, an inner or dorsal chamber and an outer or "ventral one. They contain blood. Each chamber is "bounded above and below by a thin line. It results from "this that the cavities of the two chambers are separated by "a double wall. This appears as two fine parallel lines be- "tween which is a very narrow space. Lying in this space "and occurring at frequent intervals are elongated nuclei. "The outer walls of each chamber lie immediately within "the hypodermic (epithelial) layers on the respective dorsal "and ventral sides of the gill. The outer walls have nuclei, "but they occur at widely separated intervals. The hypo- "dermic pillars cross the blood chambers. Where they occur "the walls of the chambers curve round them, forming "sheaths. Thus the cavities containing blood are every- "where separated from the hypoderm by a boundary wall."

Here are several inaccuracies:—The main portion of the exopodite is certainly a simple cavity crossed by pillars lined by epithelium, thicker on the dorsal than on the ventral side (Fig. 16). In the proximal part of the exopodite and in neighbourhood of the special part this thin partition is present, but not in every part of the exopodite. The nature of this partition; its simplicity in structure to the tissue in the body cavity; its presence in the protopodite and in the proximal portion of the appendage as a blood directing tissue; its presence in the basal part of the endopodite as well; and the fact that a similar tissue is found in *Asellus* and other aquatic isopods are points with which Stoller does not seem familiar. Then he is mistaken when he mentions that the blood cavities have definite boundary walls, that is of cellular structure, other than the epithelial lining and in some cases the intermediary tissue. He, himself, is evidently in doubt as to this, for in a footnote on page 14, added after the treatise was written, he leaves the question undecided. The footnote is meant to qualify the following statement:—

"The blood cavity occupies the whole space within the "hypodermic layer, and is bounded by a very thin wall lying "contiguous to the hypoderm and conforming to its irre- "gularities. In this wall at long intervals lie elongated "nuclei. I infer from the relations of this wall that it is "of mesodermic origin." (Stoller.)

In the footnote he refers to the work of Leichmann, who has described the brood pouch lamellæ of *Asellus aquaticus*,

and who found them homologous in structure to the branchiæ, with a simple blood cavity bounded by epithelium. The inner surface of this has a very thin cuticle. Kimus describing the exopodite of *Asellus aquaticus* says:—

"Rappelons que les parois des cavités sanguines sont "formeés dans la plus grande partie de leur surface, par "les deux lamelles épithéliales tapissées intérieurement d'une "mince cuticule."

This very thin cuticle is more evident in some species, e.g., *Porcellio scaber*, and it is this that Stoller has taken to be a definite cellular layer of mesoblastic origin. This mistake runs all through his treatise, his figures too are incorrect in this particular, but perhaps the most serious of the errors into which he has fallen has reference to the minute anatomy of the special part of the exopodite; serious because it has found its way into such a textbook as "A Treatise on "Zoology," Part VII.

He divides the internal cavity of this part into five separate chambers, one below the other, three of these are blood chambers and two are air chambers.

He states (pp. 26 and 27):—"The dorsal and ventral "blood chambers of the general part of the gill are con- "tinued into the special part of the gill. But in the special "part there is present, in addition, a third blood-chamber, "which lies between the other two. This middle chamber is "formed by the forking of the partition separating the "dorsal and ventral chambers in the general part. Each "branch of the fork retains the structure of the main parti- "tion; that is to say, consists of a double wall, with nuclei "lying in the narrow intervening space. While the dorsal "and ventral chambers are thus separated along their lateral "faces they communicate with each other in certain places "at the margin of the gill."

Then follows a description of the possible communications between the dorsal and ventral chambers, and this so-called middle chamber, which I need not quote. He then proceeds:—

"In addition to the three blood-chambers in the special "part of the gill there are other chambers which contain "air. These are two in number, situated one on the dorsal "and one on the ventral side of the gill. The dorsal air- "chamber is bounded outwards by the wall of the gill and "inwards by the outer wall of the dorsal blood-chamber.

"The ventral air-chamber has corresponding relations. In "other words, in the special part of the gill there is a space "between the general wall of the gill (composed of chitine "and hypoderm) and the boundary wall of the blood-cavity, "and this space contains air. This space does not com- "municate by any opening with the outside of the gill."

Stoller supports these observations by a number of experiments:—

"As has already been stated, when an animal is placed "in water the appearance of air in the gills passes away. "This observation led to a number of experiments, the chief "purpose of which was to gain evidence, in addition to the "evidence derived from direct inspection and from the study "of the structure of the gill, that air is normally present in "the chambers.

1. "An animal was placed in water until the appear- "ance of air in the gills had passed away. It was then "killed, and the tissues fixed by hot 33 per cent. alcohol. In "sections of the gills prepared from this specimen the air- "chambers did not appear empty (as usual), but contained "blood without corpuscles, that is, blood plasma (appearing "as granulated matter).

"This experiment, having indicated that under the con- "ditions imposed the air was replaced in part, at least, by "plasma of blood, we next sought to modify the experiment "in order to ascertain whether the presence of blood in the "chambers was due entirely to the conditions being "artificial.

2. "The preceding experiment was repeated, excepting "that the animal was placed in normal salt solution instead "of water. The result was that the chambers contained "blood plasma, but perhaps less in quantity than in the "previous case.

"In this case the two fluids were of approximately equal "densities and, it may be inferred, tended to replace the air "in equal measure. Allowance must be made, however, for "the greater thinness of the wall bounding the blood-cham- "ber than the outer chitinous wall.

3. "The experiment was repeated, using a concentrated "salt solution. The result was that the chambers appeared "as empty or nearly so, little blood plasma having entered "them.

"In this case it would appear that the more concentrated "fluid replaced, in the main, the air. In all three cases the "results became intelligible on the supposition that the "chambers contain air. Thus, these experiments warrant "the inference that the chambers normally contain air and "not blood." (Stoller.)

Now let me take some of the points raised in the above excerpt—

I do not agree with the description of the partition in the special part. In most sections the partition seems to me to be a single structure composed of two closely applied very thin strands containing elongated nuclei. In some sections the two strands are rather more separated than in others, but I cannot find anything which can be called a middle chamber. The partition here does not differ materially from the partition in the ordinary part, indeed the two partitions are continuous. I have failed absolutely to find the two air-chambers either by surface observation or by sections or by the experiments suggested by Stoller.

In the paragraph from his treatise quoted above, he describes these chambers as being bounded by the epithelium of the outer wall on one side and the wall of the blood cavity on the other. We have already seen that he is in error in describing a definite boundary wall to the blood cavities, and this initial mistake may have led him into the further error of finding air within the appendage. Certainly there is no wall between his so-called air-cavity and the blood cavity: it was not surprising, therefore, to find blood in these cavities.

I have tried every way I could devise to test the question, but have failed to find any air inside the appendage, and I feel convinced that his observations are incorrect, and that the internal cavity of the special part of the exopodite is simply divided into dorsal and ventral blood chambers. In all my sections I have found blood corpuscles in these chambers. Possibly the idea arose after looking at a section in which the protoplasmic lining had contracted leaving a space between it and the chitinous cuticle. This does take place—due, I suspect, to a too rapid method of dehydration or faulty fixation—and this appearance would certainly result after the use of salt solution.

Really a few minutes' observation of a living creature submerged in water and so arranged that the ventral surface of the abdomen can be viewed in a good light would convince anyone that there is no air inside the walls of this

special part, but only outside. The following simple observation could be made as well. Take off any one of the exopodites from a living specimen, dip it into alcohol to remove the surface air which clings to the corrugated surfaces, and mount it in water. This need not take more than 30 seconds at the most. The special part of the exopodite is quite transparent, there is no trace of air when seen by transmitted or reflected light. Now, if there were air-chambers, as Stoller suggests, it would have been impossible for the air and water or air and alcohol to have interchanged so rapidly, especially as Stoller agrees there are no openings, and that any interchange must take place by diffusion.

Having convinced myself that Stoller is wrong in his account of these air-cavities, there is no need to follow him further, and point out the errors in his account of their physiological function, for it is based upon error.

Although claiming for these special breathing organs a simpler structure, they are still very wonderful adaptations and illustrate another method whereby gill plates can be used for air-breathing. It is interesting to find these adaptations and to compare them with similar contrivances in other members of the *Arthropoda*. It has seemed to me that the lung books of Spiders may have much in common with the branchial plates of land Isopods.

Before leaving the question of the exopodites, I want to point out a peculiarity associated with the last pair of plate-like abdominal exopodites (that is of the 5th abdominal appendage). The under or dorsal surface of one of these appendages is shown in Fig. 10. There is a curious arrangement of long spines or hairs, which occur in radiating groups in a special band across the exopodite. The arrangement suggests a cheval-de-frise, especially as it occupies the place, just posterior to the endopodite, where protection might be necessary. It is difficult to be sure as to the function of this formidable array of hairs. Protection from enemies or from the "excreta" discharged from the anus, which is close by, do not seem sufficient, and their absence in *Trichoniscus* is against these uses. The only suggestion which occurs to me as likely is the possible use in preventing the drying up of the film of water which covers the endopodites, seeing that the last pair are more exposed when the plates are lifted and when the end of the abdomen is flexed.

The Endopodite: The endopodites of *Oniscus* are smaller in proportion to their exopodites in surface area than those

of *Trichoniscus*. This is possibly due to the fact that the exopodites have a greater respiratory importance in the former species. Figs. 10, 15, and 16 will give a good idea of its shape and structure. It is little more than a squarish thick walled bag, the cavity is the blood cavity, and it is crossed by pillars. There is little to add to the description already given for *Trichoniscus*, except to note the larger size of the pillars and the fact that they are more numerous. The pillars are of the same character as described in the case of *Trichoniscus*.

3. *Philoscia muscorum* (Scop.).

Pl. XII., figs. 17, 18.

4. *Philoscia couchii* (Kinahan).

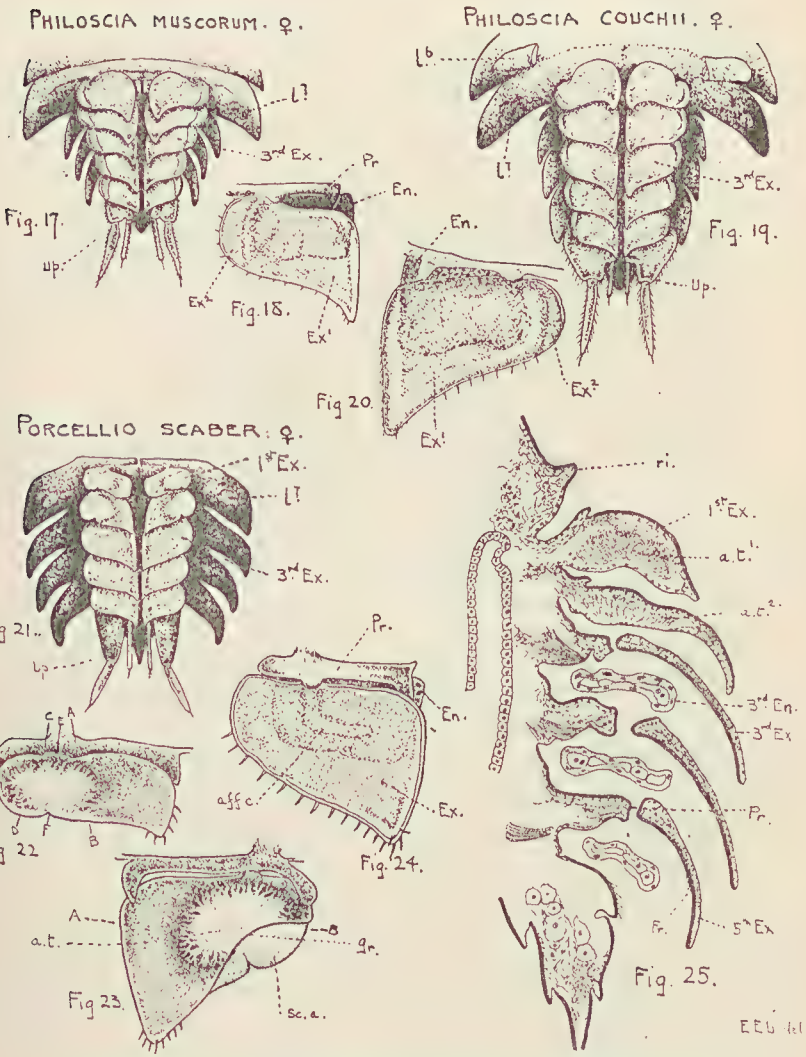
Pl. XII., figs. 19, 20.

The general arrangement and structure of the respiratory appendages of *Philoscia muscorum*, are the same as in Oniscus. Fig. 17 shows a ventral view of the abdomen of a female, and Fig. 18 the 3rd abdominal appendage seen from the ventral aspect. These figures serve to indicate its likeness in details to *Oniscus*. The exopodite with its special respiratory organ, and the endopodite are so similar in structure and function to those already described for *Oniscus* that there will be no need to repeat any part of it here.

The exopodite of the 5th abdominal appendage also shows a similar cheval-de-frise on the dorsal surface.

Philoscia couchii: The general arrangement and structure of the respiratory plates are similar to those of *P. muscorum*; but the special respiratory organs of the exopodites are poorly developed. Fig. 19 shows a ventral view of the abdomen, and in this figure and in Fig. 20 the character of the exopodite can be seen. The endopodites seem rather larger in this species. The structure of the special border organ, although much smaller in size, is identical with that of *Oniscus*, or *P. muscorum*.

I can find no trace of the rows of special hairs—the cheval-de-frise on the exopodite of the 5th abdominal appendage. This fact seems to support the suggestion made that they have some function in connection with respiration, in protecting the cavity in which the last pair of endopodites are found. The very damp habitat of this species making such protection unnecessary.



Philoscia muscorum ♀, *Philoscia couchii* ♀, and *Porcellio scaber* ♀.

NATURAL MUSEU

5. *Porcellio scaber*, Latr.

Pl. XII., figs. 21-25; Pl. XIII., figs. 26-40.

Fig. 21 gives a ventral view of the abdomen, and from this figure and the longitudinal section drawn in Fig. 25 it will be seen that, apart from the white patches of the first two pairs of exopodites, the general arrangement is similar to that described in the other woodlice.

We have to deal here with two distinct methods of respiration. There is the method similar to that described in *Trichoniscus*, using the endopodites and exopodites of the 3rd, 4th, and 5th abdominal appendages, and then the special method which is developed in connection with the air-trees or air-sponges carried by the exopodites of the 1st and 2nd abdominal appendages.

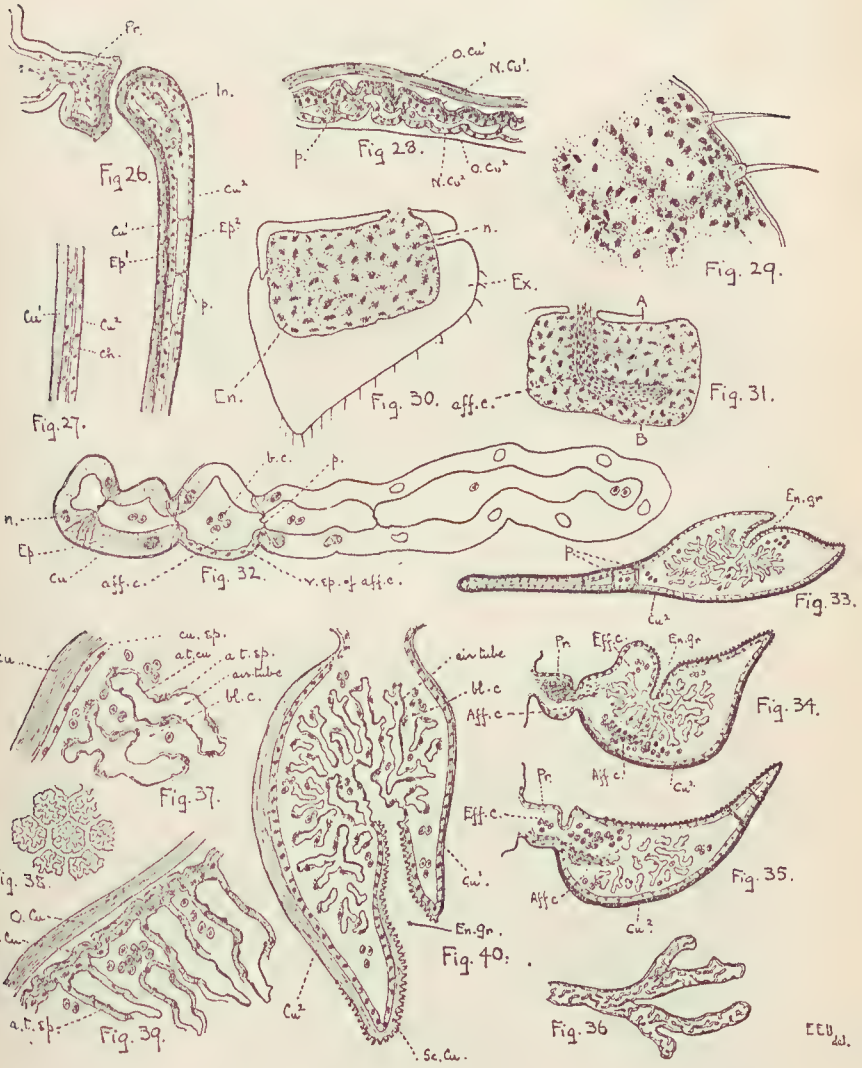
It will be best to examine the more normal method first and for this purpose we will take the 3rd abdominal appendage. The general shape of exopodite and endopodite can be seen from Figs. 24, 30, 31, so that a description need not be given. At first sight there seems but little difference from the structure which we look for in these parts, but both exopodite and endopodite present peculiar features. When the exopodite is examined under the microscope, either in the living condition or after treatment with methylene blue, it is evident that the usual passages for the blood, the afferent along the inward border, the efferent along the outward border, and others traversing the central part, are not present. The exopodite seems to be much more of a regular mass of cells, and only in the proximal part can one make out any sign of blood spaces. These are few, and do not extend far into the exopodite. Fig. 29 gives some idea of these blood spaces seen from the ventral surface. The epithelium appears to be gathered into partitions dividing the cavity into a number of small galleries. Some observations upon the living creature will now be described. I have found it best to use a hollow-ground slide—varying the size of the hollow to suit the size of the woodlouse—and using a rather thicker cover-glass held down by two pellets of paraffin wax. The wax can be melted by a mounted needle, and the height of the cover-glass adjusted so as to restrain the creature with its ventral surface uppermost. It is always best to remove carefully the last two pairs of legs, for they are apt to obscure the abdominal plates.

The breathing action of the exopodites is very evident, and even in such a "dry" species as this, there is a film of water covering the endopodites and the dorsal surface of their exopodites. The film can be seen alternately retreating and advancing as the exopodites are raised and lowered. If working with a table lamp the heat from this is sufficient to cause some evaporation of this water, and one can see the air gradually working its way under the exopodites, as the water recedes, until there is a large bubble of air in the space between the exopodite and the ventral wall of the next exopodite. This air bubble expands and contracts as the exopodites move. When the air has gained access to the space under the exopodites, the silvery appearance of the exopodite resembles very closely the special segment of the exopodites of *Oniscus*, to which attention has already been directed, and confirms the point that their appearance is due to the air imprisoned under those special edges.

The creature in this position is useful for showing the circulation of the blood in the exopodites, and it is usually advisable to run in water under the cover-glass so as to submerge the animal and get rid of the surface reflections. It is interesting in passing to note that when it is submerged, the movement of the exopodites is much more marked. They become widely separated at each movement, no doubt owing to the ease with which they can be moved in the water, and not because of any increase in muscular action, for if the water is drained away, the amplitude of the movements is once more reduced to the normal. It is important to remember that air can gain access more easily than water, and the slight movement of the exopodites sufficient for the purpose of the necessary exchange, will also prevent the desiccation of the endopodites. The circulation of blood in the first two pairs of exopodites will be referred to later. We are concerned with the exopodite of the 3rd and the next two abdominal appendages. I have watched both males and females for hours, but have failed to detect any circulation in the distal region of the exopodites. In the proximal region now and again a blood corpuscle could be seen threading its way from one side to the other, but there is here nothing comparable to the circulation which can be seen in *Trichoniscus* or *Oniscus*.

In the sections examined very few blood corpuscles have been found in the exopodites, indeed the epithelial linings of the two faces are so closely applied, save in the proximal region, that the large corpuscles could not pass through the

PORCELLIO SCABER ♀.



Porcellio scaber ♀.

cavity. It is only in the proximal region that there is a normal blood cavity. However, at one special period there is a considerable amount of blood found in the exopodites, and this is when a new chitinous cuticle is being secreted by the epithelial layer. I was fortunate enough to get one or two specimens in this condition, and the sections through the abdominal appendages have been most instructive. If Figs. 26, 27, and 28 are studied, these points are still further illustrated. Fig. 26 shows the protopodite and the proximal one-third of the exopodite in longitudinal section. The epithelium is shown in too dense and definite a form for a normal exopodite. It is like that when the new cuticle is formed, and then the protoplasm becomes vacuolated and stringy, and the exopodite appears in section like Fig. 27. The epithelium has, however, a very definite inner wall, and appears rather like an extremely thin layer of chitin. This persists, and seems especially distinct in *Porcellio*. It is probably this inner boundary of the epithelial cells which led Stoller astray, and induced him to describe it as a distinct layer of elongated cells forming the wall to the blood cavity. Also, there are little irregularities which might be taken for tiny nuclei by a casual observer, but there are no nuclei there, and the whole structure is very clear when exopodites in different conditions are examined. Fig. 28 gives the appearance when a new cuticle is being formed beneath the old one, and it is at such a time as this that blood corpuscles are found in the internal cavity. It is by a comparison of such an exopodite with one during the intermoulting period that the real meaning of this definite boundary is understood. In the distal part of the exopodite the two epithelial layers come so near to one another that the two boundary lines give the appearance, under the low power, of a median line dividing the exopodite into two, but this is not really so. (Fig. 27.)

Both the chitinous cuticle and the epithelium are thicker on the dorsal or inner side. This conforms with the general rule for woodlice, and Stoller's mistake with regard to this has already been referred to. There is no need to repeat his words here.

In the proximal region, especially in the part near to protopodite, a little intermediary tissue can be seen. (Fig. 26.) It blocks up what would otherwise be a large cavity, and so retards the flow of blood both in the protopodite and the exopodite. Another unusual feature is the poor development of the pillars. There are very few pillars, and those

that are present appear to be a simple fusion of the epithelial cells of each face, and nothing of the definite structure, which we have referred to in the other forms, is visible here. They cannot be traced from cuticle to cuticle, and are of the simplest form; indeed they appear to be degenerate, for they are much more evident in a specimen which is forming a new cuticle. (Fig. 28.)

This exopodite, as well as those of the next two appendages, was probably useful for respiratory purposes at one time. The very thin chitinous cuticle on the ventral surface points to this, but in course of time when the exopodites of the first two abdominal appendages developed the efficient air-tree organs, it was more economical to concentrate the blood supply in these special organs; consequently the respiratory function of the 3rd, 4th, and 5th pairs of exopodites, became less important, and degeneracy of pillars and epithelium would naturally follow.

The inner or dorsal surface of the 5th pair of exopodites has the curved rows of special hairs, similar to those described under *Oniscus asellus*. Also on the ventral surface of the abdomen at a place covered by this part of the exopodite, there are found large backwardly curved setæ. (Fig. 25.)

The Endopodite: The endopodite is, except in one important particular, similar to that described under *Trichoniscus* and *Oniscus*. It is a flattish bag with thick spongy walls, which are composed of a very thin chitinous cuticle, and a thick epithelial layer containing large nuclei. A few pillars join the cells of the two faces. In these things it is typical. The protopodites which carry the exopodites and endopodites stand out well from the ventral surface, and thus form between adjacent protopodites and exopodites a series of pockets in which the endopodites lie. This arrangement can be seen in Fig. 25, but the exopodites and endopodites in that drawing are not in their natural positions for the killing and subsequent operations incident to sectionising cause the exopodites to gape. In life the exopodites are found resting on one another, and this will close the pocket in which the endopodite rests.

It is usual to find that a mass of intermediary tissue directs the course of the blood as it enters the endopodite from the protopodite, in such a way that the blood will pass down the inward border and out along the outer border. Here there is something quite different.

When the endopodite is examined as a flat object under the microscope, especially after treatment with methylene blue, a curious curved finger-like mark is seen bent to form the letter L. The mark runs from the place of articulation directly backward and then turns towards the inner border. At first sight this had the appearance of a process of cells pushed into the cavity of the endopodite, but neither dissection nor sectionising showed any intermediary tissue either in the proximal or distal region of the endopodite. The sections, however, did show that this appearance was due to a tube with a special wall. If the endopodite is examined with the dorsal surface uppermost, the wall in the region of the tube is in no way different from that of the rest of the face; but if the ventral surface is examined, the thick, large-nucleated cells of the endopoditic epithelium give place to small thin cells with small nuclei in the part where this special tube is situated. This can be seen by altering the focus and bringing into view alternately the dorsal and ventral walls of this tube. Thus, there is a wide tube or channel running from the protopodite into the middle of the endopodite, and this channel is bounded by the ordinary wall on the dorsal side, by a special layer of small cells on the ventral side and laterally by the more or less opposed walls of the epithelial cells with frequent pillars joining the two sides together. The relations of this channel have been followed through a series of sections, and reference to Figs. 31 and 32 will suffice to make clear this unusual feature. This channel is an afferent blood canal bringing blood into the middle of the appendage, and is an effective way of regulating the flow of blood. Stoller gives no hint of this structure in his reference to the endopodite.

The Exopodites of the 1*st and* 2*nd Abdominal Appendages*: We must now consider in detail the interesting breathing organs which are found in the first two pairs of abdominal appendages. They appear as whitish marks to the naked eye, and as air-trees or air-sponges when examined under the microscope. They are an attempt at a more satisfactory method of breathing, and aim at bringing the air and the blood into closer relationship by means of invaginations of the outer wall.

One is reminded at once of the tracheal tubes of insects, but here we are faced with an independent and very much less perfect method and one, furthermore, which is very much restricted; for the air only enters into a part of four abdominal plates, whereas in insects the tracheal tubes ramify

throughout the body. The blood in woodlice is therefore of the more importance as a carrying agent of oxygen from these special breathing organs to the rest of the body. These air-tree organs are found in both male and female, and are essentially the same, so that a description of the female exopodites will be given.

Figs. 22 and 23 give a general appearance of these air-tree organs as seen from both the ventral and dorsal aspects. Fig. 22 represents one of the first abdominal exopodites, ventral aspect; Fig. 23 one of the second exopodites, dorsal aspect.

Only a brief account of the general structure of these organs, sufficient to enable anyone to follow the detailed description, is necessary. The cavity of the exopodite is invaded by a tree-like invagination of the wall, and this causes a wide separation of the dorsal and ventral surfaces of the exopodite. The entrance to the air-tree is on the inner or dorsal surface, a little way from the outer posterior border, and the actual entrance is situated in a transverse groove, the opening of which points backwards. The place of the actual opening into the air-tree is indicated by a notch in the ventral posterior border. This notch is very conspicuous in the exopodites of the 2nd abdominal appendage (Fig. 23).

The chitinous cuticle, which is more or less sculptured in all parts of the body, has a very characteristic pattern in the region of this groove. Fairly deep furrows divide up the thickened chitin into hexagonal areas which carry a maze-like arrangement of narrow ridges. Fig. 38 shows a few of the hexagonal patches seen from above. In section the chitin has the appearance of flat-ended processes carrying hairs (Fig. 40). The limits of this specially sculptured chitin are important. Starting from the dorsal edge of the groove, it covers both the sides of the groove and extends to the posterior ventral border and round on to the ventral surface for a short distance. Fig. 40 shows the distribution as seen in a section taken along the line EF in Fig. 22.

The air-tree occupies rather less than half the area of the exopodite. The remaining part is more or less typical in structure, except that, as compared with the exopodites of the 3rd abdominal appendage, there are better pillars and a wider blood cavity. When a living specimen is under observation, it is easy to see that blood corpuscles do penetrate into the normal part of the exopodite, going some little way before sweeping round towards the air-tree, the destination

of the blood. The pillars are interesting because of their degenerate condition in the other exopodites. Large, well-defined pillars, running from cuticle to cuticle, mark the place of transition from the swollen, air-tree part and the narrow, normal part; other smaller, yet very well defined, pillars, are scattered near by. Fig. 33 represents a transverse section through such an exopodite as is shown in Fig. 23, the line of section being along the line AB.

It should be noted that the exopodites of the first and second abdominal appendages have thicker chitinous cuticle on the ventral than on the dorsal surface. This exception to the general rule (Fig. 40) has to do with the method of changing the air in the air-trees. This will be discussed below. It has already been pointed out that the amount of blood passing through the exopodites of the 3rd, 4th, and 5th abdominal appendages is very much less than the amount passing through the same exopodites in *Oniscus* and *Trichoniscus*. When, however, we examine the exopodites of the 1st and 2nd abdominal segments in *Porcellio scaber*, a very different state of things is found. In these exopodites there is a good and constant circulation. The blood enters the exopodite by a definite passage or channel from the protopodite on the ventral side of the appendage, and finds its way through the meshwork of air-tubes to the dorsal and posterior side, where, collecting in a large blood space which runs along anterior to the large groove, it passes out by another definite channel into the protopodite and so back to the pericardium and heart. The intermediary tissue or tissue of the body cavity is the limiting tissue of these afferent and efferent blood channels. One can see the blood rushing into the exopodite, and the major part of it at once becoming entangled as it were in the maze of blood passages caused by the branches of the air-tree; some of it, however, as we have noted, travels out into the flatter part and then works back to the air-tree, entering the maze of passages at the side. The blood corpuscles slowly thread their way among the air-tubes until lost to sight in the depths of the tree.

By examining serial sections taken across such an exopodite further details can be made out, and in Figs. 34 and 35 two out of such a series are given. Fig. 34 representing a section taken along the line AB in Fig. 22 shows the afferent channel on the ventral side, leading into a large blood space or sinus from which the blood will be distributed to the air-tree organ. The dorsal sinus (eff. c.) is also shown. In Fig. 34 representing a section taken along the line CD, nearer

the outer border, we see the end of the dorsal sinus and the efferent channel leading from it out into the protopodite. I have given the circulation in some detail, for Stoller in his account does not deal fully with it. The function of the dorsal sinus or collecting chamber, which is so important in connection with the even passage of the blood through the sponge-like mass, has been misunderstood by Stoller, who also presents what I feel is a mistaken explanation of the special sculptured region of the chitinous cuticle which surrounds this sinus and the entrance to the air-tree. He looks upon these two things, the dorsal blood space and the grooved wall, as furnishing an important subsidiary respiratory organ. It will be best to quote one or two paragraphs from his thesis:—

"That the larger furrows or grooves separating the polygonal areas contain air may be demonstrated by mounting a gill in water, when they are seen to appear white by reflected and dark by transmitted light. If a gill is placed in alcohol before examining, the network does not appear dark under transmitted light. The finer furrows of the polygonal areas do not appear to hold air." (P. 13.)

"It is evident that the gill of *Porcellio scaber* is a structure adapted to bringing the blood into relation with air. Two different and independent anatomical structures are employed in order to secure a ready exposure of the two media to each other. These are first, the net-work of furrows in the chitine at the exterior of the gill, and second, the unfolded portion of the chitinous wall, forming the internal tree." (P. 15.)

"Applying these principles (i.e., permeability and strength) we see that in the specially modified portion of the chitinous wall at the exterior of the gill increase of surface and at the same time thinness of wall is secured through the furrowing of the chitine. Furthermore, the furrowed structure is that which in the least degree compatible with the attainment of these two ends detracts from the strength of the wall. The arrangement of the furrows in a net-work is adapted to securing the largest linear extent of grooving, and at the same time the least sacrifice of strength of the wall. The shape of the furrows which as seen in section (Fig. given) is that of an oval with the long axis at right angles to the face of the wall is, I conceive, adapted to a threefold purpose, namely: first, to contain a large amount of air relative to the space oc-

"cupied; second, to retaining this air in the groove (by "means of the narrowing of the opening); and third, to re- "duce to the least extent the strength of the wall (by means "of the resistance to fracture secured through the curved "surface to the oval).

"The tree, as a mass, is somewhat spherical in shape "which secures the most favourable distribution of the "branches in the fluid surrounding them. But the sphere is "depressed on the basal side of the tree, leaving a space be- "tween the base and the grooved area of the wall of the gill. "It is evident that this is an adaptation for bringing a re- "latively large amount of blood into rotation with the air "contained both in the grooves and in the basal branches of "the tree." (P. 16, Stoller.)

The special sculpturing of the chitin around the entrance to air-trees is to keep them free from the danger of becoming clogged by water. If a specimen, secured in the way already described, so as to exhibit the ventral surface of the abdomen, is flooded with water, it is clear that unlike the rest of the body, the chitin of these special regions of the first two pairs of exopodites, is not easily wetted. It will be remembered that the special sculpturing extends some little distance on the ventral surface, and it is easy to see the air clinging to this part and keeping the water away from the entrance to the air-trees. If one of these exopodites is removed and mounted in water, it is possible to examine it under the high powers of the microscope and to see that there is certainly air retained in the smaller furrows upon the hexagonal areas just as there is air in the wider furrows between the hexagonal areas. Stoller is not correct in thinking that these smaller furrows do not retain air. It is very easy to demonstrate that they do, by exchanging the water for alcohol and watching the effect. With care, the water can be withdrawn and alcohol substituted without disturbing cover-glass or exopodite. As the alcohol begins to flood the exopodite the air is driven out of both the larger and the smaller furrows. It is obvious that air in these smaller furrows would be useless for respiration.

Then again the distribution of this specially sculptured chitin points to a different use from that suggested by Stoller. Not only is it found on both sides of the entrance groove leading into the air-tree, where the chitin is very thin below the larger furrows, but it extends round the posterior and outer edge of the exopodite and on to the ventral surface,

where the chitin is very thick. Then the rest of the dorsal surface, especially the part just anterior to the edge of the groove, is smooth and thin. There is a blood cavity within the appendage at this place, and if the sculpturing aided respiration this seems the very place to have it (cf. Pl. XIII., figs. 34, 35, and 40).

The use of this elaborate sculpturing of the chitin is to prevent water from clogging the entrance to the air-tree, and thus stopping the free current of air so necessary for efficient respiration. It is interesting to remember that aquatic insects exhibit a somewhat similar device for preventing water from entering the spiracles.

The position of these air-tree-holding exopodites so near the ground, and the fact that the other breathing organs, the endopodites, are only functional when coated by a film of water, make some protection essential to the success of the air-trees.

With respect to the minute anatomy of the air-trees I am again in disagreement with Stoller's account. He says, on p. 15:—"The walls of the tubules are thin and show no mark-"ings. Lying outside of the chitinous layer is the likewise "thin hypodermic layer. Outside of this and closely "associated with it is the boundary wall of the blood cavity. "Thus, every portion of the wall of the tree is composed of "three very thin layers. The hypodermic nuclei occur at "frequent intervals." (Stoller.)

There is no need to refer again here to the question of a definite wall to the blood cavities. It has already been shown that this does not exist. There are but two layers separating the blood cavity and the air-tubes, the epithelial (or, to use Stoller's term, hypodermic) layer and its chitinous cuticle. However, as in the other places, this epithelial layer is usually reduced until it appears that only a very thin layer of chitin separates blood and air, but the nuclei of this epithelial layer are prominent, and at certain times the whole layer is very evident. When a new cuticle is being formed beneath the old one, the epithelial layer is seen to best advantage, and Fig. 39 shows a section through a portion of the air-tree of a specimen in this condition. The normal condition of the air-tree in section is shown in Fig. 37. The epithelial layer is much reduced, except the layer which is beneath the surface cuticle.

Further, I do not agree that the chitinous walls of the air-tubes—the branches of the air-tree—are smooth. I

find that the walls of all these air-tubes, both great and small, are thrown into ridges which remind one of the ridges upon the surface of the hexagonal areas on the chitin around the entrance to the air-tree.

In another place in his thesis Stoller, speaking of these air-tubes, says:—"The whole structure appears to be hol-"low, with smooth thin walls. The appearance of irregular "markings on the walls is probably due to shrinkage, con-"sequent upon the passing out of air." (P. 13.)

I have examined a very large number of these air-tubes under every kind of condition, both living and dead, with air inside and without air, as flat objects and in section, and I find that the walls have this distinct pattern of ridges. Fig. 36 shows the appearance when the tubes are full of air; and in the various figures of sections across the air-tubes the same irregularities of the wall are indicated (Figs. 37 and 39).

The presence of this distinct pattern on the chitinous lining of the air-tubes is most interesting in comparison with the structure of the tracheal tubes of insects.

The great problem for solution, to which Stoller makes no contribution, is the effective renewal of air in these air-trees. I believe that this pattern on the walls of the branches of the tree plays a part similar to that played by the spiral thread in the insect's tracheal tubes. *But where does it get the pressure?* There is no internal mechanism. At one time I wondered whether there would be pillars running across the swollen area, but this is not so. The only pillars are found in the more normal parts, and their operations would have little effect upon the air-tree organ. Could there be any other way of bringing pressure to bear upon the exopodite? There is the lowering and raising of the exopodites, the normal isopod breathing action, but as we have seen, this movement is very slight in these land-forms, and in the first two pairs of abdominal appendages, the air-tree exopodites hardly move at all. This does not seem effective. The clue came to me whilst watching a number of *Porcellios* which I had placed in different vessels for experiments in duration of life under different conditions of dryness, and varying amounts of carbonic acid gas, and also in water. When the creatures were in difficulty with their breathing, I noticed that the whole abdomen was alternately raised and lowered in an unusual manner. This was especially evident in a specimen placed in carbonic acid gas. When

the abdomen was raised and extended the exopodites stood well out from the ventral surface, somewhat as they are drawn in the longitudinal section shown in Fig. 25. When the abdomen was lowered and contracted the exopodites were pressed tightly against one another, and the transverse ridge seen in Fig. 25 as a process just anterior to the 1st exopodite, was pressed against the 1st exopodite.

By experimenting with an inverted woodlouse in a glass cell, which allowed a certain play of the abdomen, I was able to confirm the above statement; and by submerging the creature could get evidence of the effect of the pressure upon the air-tree organs. The ventral wall of those exopodites which bear the air-tree organs, is very thick, whilst the dorsal wall is very thin. (Figs. 40, 34, 35.) The attachment to the protopodite is such that any external pressure would cause the exopodites to respond readily to it. Indeed, the shape, the way in which they press against one another, the transverse fold of the ventral wall which abuts on to the ventral surface of the exopodite of the first abdominal appendage, all support the above suggestion that pressure is exerted by flexion of the abdomen.

The next point to consider was the effect of the pressure upon the air-tubes inside. One of the easiest ways of seeing this, is to remove one of these exopodites from a living *Porcellio* and examine it under the high power of microscope. By cotton wool or some such substance, the cover glass can be kept from pressing on to the exopodite, until such pressure is required. When slight pressure is exerted on to the cover glass, the effect can be watched. The air is seen to leave the finer tubes or branches, and then return when the pressure is relaxed. By careful observation it is clear that the character of the wall of the air-tubes in being strengthened in the way already referred to, is responsible for this return to the normal condition. The ridge-like markings on the walls enabled the tubes to spring open again when the pressure is relaxed, and so allow the air to return unobstructed. Without some such arrangement as this, it would be impossible to get the air into these very minute air tubes.

The pressure on the surface walls of the exopodite will be conveyed by the blood in the blood cavities which surround the air-trees, to the larger and smaller air-tube branches of the air-trees. It seems clear that the mechanism for bringing about the exchange of air in the air-tree is external pressure brought to bear upon the exopodites, by the flexion of the abdomen.

It may be that the legs also play some part in bringing pressure to bear on these air-tree-holding plates, for the last two pairs of legs, when the creature is at rest, are carried bent inwards so that the basipodites rest upon these first two pairs of exopodites. When *Porcellio* is disturbed, the creature usually tries to disarm suspicion and to protect itself by an attempt to roll up the body; the legs are all bent inwards and pressed tightly against the ventral body wall, and the body is flexed to such an extent that it often rolls over on to its back. This special flexion of the body will bring considerable pressure upon the first two pairs of abdominal appendages, and although the action is primarily one of defence, it cannot fail to be of use in respiration.

The whole question of the flexion of the body, carried to far greater lengths in *Cylisticus convexus* and in the *Armadillidia*, is of considerable interest and is, I believe, correlated with this new method of respiration. The matter will be discussed when these other genera are under review and when the whole question of respiration is discussed in its relation to the habitat of the various forms, in a further communication.

6. *Cylisticus convexus* (De Geer).

Pl. XIV., figs. 41-48.

The arrangement and disposition of the abdominal appendages is similar to that described in the other woodlice, except that the lateral plates of the 3rd, 4th, and 5th abdominal segments bend downwards, so as to make a shallow cup-like cavity in which the abdominal appendages lie. This is shown in Fig. 42. A ventral view of the abdomen is shown in Fig. 41, and the five pairs of air-tree organs are indicated.

The 3rd Abdominal Appendage: Fig. 43 gives a ventral view of this appendage. From this the general details of shape and relation of the parts can be determined.

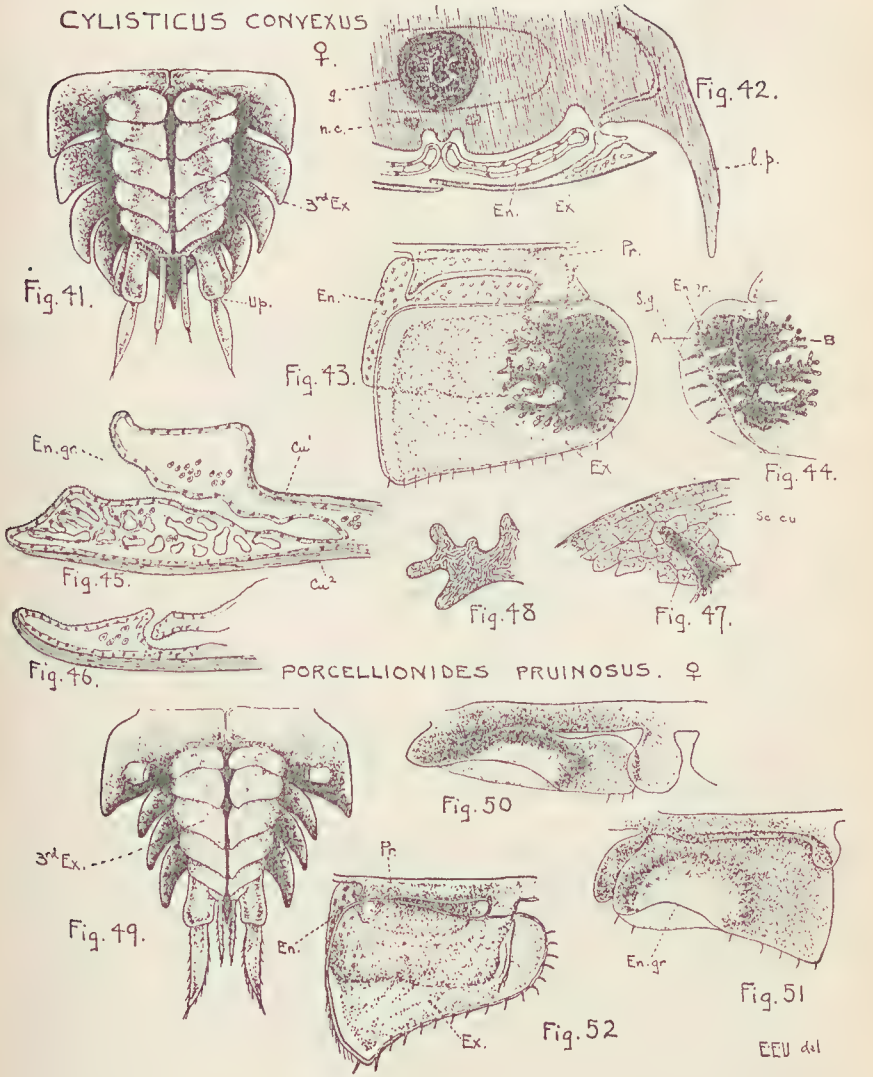
The Exopodite: The exopodite is divided into two regions: the normal, thin, plate-like part and the special swollen part containing the air-tree organ. This latter part is towards the outer border of the exopodite and extends over rather less than half the area of the exopodite. The size of this swollen part diminishes somewhat in the 4th and 5th exopodites, but is about the same size in the 1st two pairs of abdominal exopodites.

When the living animal is observed under the microscope, it is easy to see that the exopodite of this appendage

has a good blood supply, and is in this respect much more like *Oniscus* than *Porcellio*. There is a constant and a vigorous stream of blood flowing towards and through the air-tree organ much the same way as has already been described for the first two abdominal exopodites of *P. scaber*. The cause of the blood is also very much the same as already described in *Porcellio*, and is much the same in all the abdominal exopodites. The exopodite of this appendage, as well as of the next two pairs, acts as an operculum as well as an additional breathing organ, and it is so arranged that the one function does not interfere with the other. Fig. 42, in which a section through the 3rd abdominal appendage is drawn, shows this very well. The dorsal wall of the exopodite is so arranged that the alteration in levels, between the swollen air-tree part and the normal part, is abrupt. Thus the endopodite is enclosed in a kind of chamber. The openings into the air-tree organs are on the outer border well away from this chamber, which is kept very moist.

There is no need to give a detailed description of the normal part of the exopodite. It is typical with its chitinous cuticle, epithelial layers, and the pillars transversing the cavity. The dorsal chitinous wall is, in this region, thicker than the ventral one, thus conforming with what has been found to be the general rule in land isopods, but the ventral wall is not very thin, which is what we should expect seeing the respiration will be undertaken by the air-tree organs, and not take place through the ventral wall. Then as the walls approach the region of the air-tree organ, a change takes place, the chitin of the ventral wall becomes much thicker, whilst that of the dorsal wall becomes very thin. We have already commented upon this in the case of the air-tree organs in *P. scaber*, and the reason here is the same as there; the strong curved ventral cuticle, together with the very thin dorsal cuticle, enables the creature to bring pressure to bear on these air-holding appendages by flexing the body, and the appendages regain their normal shape when the pressure is relieved.

The special breathing organ will require rather more attention, for it presents some striking differences from those already described under *P. scaber*, and I do not agree with Stoller when he says that the air-tree organs are similar in the two genera. As one looks at the exopodite as a flat object from the ventral side (Fig. 43), the air-tree appears to be composed of several distinct parts, spreading out towards the middle region of the exopodite. Each of these is



Cylisticus convexus ♀.

Porcellionides pruinosus ♀.

more like a large air cavity ending in smaller branches or tubes than like a tree or bush of many fine inter-locking branches as in *Porcellio*. Fig. 43 represents this organ as seen in transmitted light, the air-holding parts appearing blackish. Towards the outer border four or five dark processes can be seen. They appear white by reflected light. The significance of these will be seen when the dorsal surface is examined. Fig. 44 shows the dorsal surface of this part of the exopodite seen also as a transparent object. It is clear that the main entrances to the breathing trees are situated in a distinct groove, a little distance from the outer border. Into this groove, which runs anterio-posteriorly, open the five or six large air trunks or cavities which have already been referred to. Then the four or five dark bands, extending towards the outer border, are seen to be grooved openings leading down into small air-tubes in the more ventral part of the appendage. These small radial grooves have a very characteristic appearance, which I have attempted to draw in Fig. 47, as it is seen under the high power. It is impossible to indicate clearly the differences in levels, as the groove deepens and widens.

I tested all these apertures with warm alcohol, and also by gentle pressure, and saw air bubbles passing out both from the larger cavities which open into the large groove, and from the small special grooves. Further information was obtained from sections. In Fig. 45 one of the large air-cavities is represented extending a considerable way into the exopodite. In Fig. 46 one of the small apertures is figured as it appears in transverse sections. It leads into smaller branched air-tubes in the ventral part of the exopodite.

The surface of the chitinous cuticle is sculptured in the region of these apertures, but the sculpturing is not nearly so prominent a feature as in *Porcellio*. The whole cuticle of these exopodites, indeed of the whole body, is sculptured to a certain extent, but it is in the region of the entrances to the air-tree organs that it becomes sufficiently prominent to hold air. It is clear that this arrangement will prevent water from easily wetting the surface, and so prevent the minute apertures of the air-tree organs from becoming clogged with water. When an exopodite, removed from a living animal, is mounted in water and examined by transmitted light, the air is seen clinging in these small grooves, and when alcohol is substituted for the water, one can watch the air being dislodged.

I mention these details again here because in Leydig's account to be referred to below, he has misinterpreted the function of these minute sculpturings.

The internal chitinous lining of the air cavities and tubes is raised into ridges, forming a maze-like pattern on the wall (Fig. 48). The use of this is the same as the similar pattern on the air-tube walls in *Porcellio* already described. I was able to see the air-cavities spring open again when external pressure was removed, and confirm the observations and conclusions reached in connection with the exchange of air in the air-trees of *P. scaber*. The question of the bringing external pressure to bear upon these air-holding bodies, is taken a stage further in this woodlouse. We have seen that *Cylisticus* can flex the body to such an extent as to bring the ventral surfaces of the head and abdomen together. This power of folding up will be valuable for many purposes, but one of these will be the pressure brought to bear upon the abdominal exopodites and the consequent exchange of air in the air-trees. There is the same prominent ridge of thick chitin situated immediately anterior to the exopodites of the first abdominal appendages, which will press against these exopodites. Of course, I do not mean to imply that it is necessary for the body to be completely flexed to bring pressure to bear on the abdominal exopodites; naturally when this is done the greatest pressure will be exerted, but any slight bending of the abdomen will have its effect upon these very spongy bodies, and a species with considerable power of flexion will more easily exert the necessary pressure. The entrance to the air-holding region is, as we have seen, quite distinct from the entrances to the damp cavities in which the endopodites are found. There is the same lowering and raising of the exopodites, which we have noticed in the other genera to allow air to gain access to the endopodites. The dorsal surface of the exopodites, indeed the whole of the ventral surface of the abdomen and the appendages, are readily wettable, with the exception of the special part at the entrances to the air-tree organs; and a distinct film of water could be seen underneath the exopodites when a living specimen was examined under the microscope. This woodlouse seemed much damper than *P. scaber*.

The exopodite of the 5th abdominal appendage has the same arrangement of long hairs on the dorsal surface as we have noticed in the case of *O. asellus* and *P. scaber*. The ridge with its rows of long seta-like hairs arranged in fan-

like groups is very distinct, and it was in this woodlouse that I first of all became aware of this special "frise" of hairs.

The Endopodite: The endopodite is very similar in structure to that of *O. asellus*. It is larger in proportion to the size of the exopodite than in that form. The same parts are found here, and need not be repeated.

The exopodites of the 1st and 2nd abdominal appendages need not be described in detail, for the structure of the air-tree organ has been given in connection with the 3rd abdominal appendage. In all essentials the air-tree organs of the whole five pairs of exopodites are identical.

Stoller in his account of the respiratory organs of this species says:—

"I have carefully examined, both as seen from without " and in section, the outer gills (i.e., exopodites) of the 1st " and 2nd pairs, and I find that in all essential respects they " are identical in structure with the same parts in *Porcellio* " *scaber*. The only differences are such as relate merely to " comparative form and size. The descriptions and figures " already given for *Porcellio scaber* are applicable to this " species, as respects all essential features of structure."

I have already shown that there are substantial differences. He continues:—

"Inasmuch as I have found the structure and relations of " the air-holding parts of the gills to be essentially different " from what Leydig describes, it may be suitable to quote " those passages of his work in which he sets forth the " results of his investigations in regard to the main points."

Then follow some thirty lines taken from Leydig's paper. I have read Leydig's paper and studied his figures, and although I agree with Stoller that Leydig is incorrect in his descriptions, I do not feel that Stoller has shown that he quite realises Leydig's mistake. Leydig describes in some detail the antennæ, the eyes, the surface of the body including the peculiar hairs on the legs, of a number of woodlice, before describing the exopodites and endopodites of *Cylisticus convexus*.

Beginning with the endopodite, his first sentence: "Es " ist dasselbe nach aussen umgrenzt von einer zarten, doch " von Porencanälen durchzetzten daher senkrecht streifigen " Cuticula, oben und unten,"

causes a doubt to arise as to the correctness of his observations, and I agree with Stoller that there are no pores

penetrating the cuticle, although the epithelial layer is certainly striated. The mistake has probably arisen by Leydig misinterpreting surface markings. He remarks that in a previous research he had found something similar in the gill plates of *Asellus aquaticus*. I have examined *Asellus* again, but cannot find what he describes, and Kimus in his valuable researches upon the branchiæ of aquatic isopods shows how incorrect Leydig's observations are. Quoting a description of the branchiæ of *Asellus* by Leydig, Kimus remarks—

"Nous reviendrons plus tard sur celle description et "nous verrons qu'elle est bien loin de nous donner une idée "nette de la structure des lames branchiales.

"L'auteur reconnaît qu'il n'est pas parvenu à inter-"préter les apparences qu'il a eues sous les yeux."

Leydig then turns his attention to the exopodite (decklamelle), and we find a similar error here, but one which is more serious because he professes to upset the observations, crude and incomplete as they are, of Lereboullet, Siebold, and Wagner, who described the "corpora alba" as branching sacs with blind closed ends. Leydig says:—

"In Wirklichkeit bestehen solche blindsackige enden "nicht."

The earlier investigators did not examine these organs closely, and do not describe histological details, consequently many of their conclusions are incorrect, but Leydig, who makes a closer examination of these exopodites and the air-tree organs, seems to me still further from the real morphological and physiological explanation of these interesting organs. In describing the surface of the cuticle he says:—

"Zerstreut über die ganze Fläche weg vertheilen sich "noch Kleine pneumatische Räume der Cuticularschicht."

The next extract from Leydig is a part of his paper quoted by Stoller. This, with one or two other extracts from other parts of Leydig's communication, will serve to explain his ideas concerning the air-holding structures.

"Dieselben Zellen scheiden an ihrer freien Fläche, inso-"fern sie die Bluträume begrenzen, eine zarte, die Blut-"gänge Auskleidende Cuticula ab und diese letztere ist es, "welche pneumatisch wird. Die Luft ist in kleinen Höhlen "der Cuticula enthalten, daher die 'feine Zertheilung' . . . . "da ja die Luft in der cuticularen Wand der Bluträume "liegt."

In the course of this description Leydig refers to a figure showing a transverse section through the air-holding part of the exopodite. From this figure and his description (a part of which is quoted above) it is clear that he has mistaken air cavities for blood cavities. The air-tubes with the chitinous wall raised into ridges which we have seen as a characteristic feature of these special organs are marked as blood vessels, and are described as such, and the chitinous pattern on the wall is looked upon as an elaborate arrangement of pneumatic pores and canals.

Near the end of the account, he again refers to this character of the chitin, and it seems likely that the property of retaining air in the fine grooves on the chitinous cuticle (to which I have referred at some length) has deceived Leydig into thinking that the cuticle is full of pneumatic spaces. He says—

"dass auch in der allgemeinen Cuticula der Decklamelle "ebensolche lufthaltige Höhlen, wenn auch nur in "Zerstreuter massiger Menge Zugegen sind."

He thus misinterprets not only the structure and function of the chitinous sculpturing both on the surface and on the walls of the air-cavities and branches of the air-trees; but also the circulation of the appendages. The blood flows in wide spaces bounded by the epithelium, and is not confined in definite tubes lined by chitin.

Stoller gives no indication of this serious error in Leydig's account and, as far as I can see, has not fully grasped the details of Leydig's description of the air-holding cuticle, for after quoting from his paper he adds:—"It is true that "the air-canals have walls of chitine secreted by the hypo- "derm, but these canals do not open outwards in pores, but "join one another inwards to form a tree-like cavity which "communicates with the outside of the gill through a single "opening." This points to the difference being merely one of the kind of exit from air-tubes, whereas Leydig denies the existence of these air-tubes altogether.

When discussing the physiological functions of the air-holding cuticle, Leydig is obviously in great difficulties, for he can see no method of getting any exchange of air in the pneumatic cuticle. One would have thought that this difficulty might have led him to experiment and in time revise his account of the organs. Instead, he doubts whether they have any respiratory function at all—

"Und sonach darf es wieder fraglich erscheinen ob die "Luft an dieser Stelle etwas mit der Athmund zu schaffen "hat."

I have dwelt at some length upon Leydig's work and Stoller's incomplete description of it, for it is very instructive to realise that both Leydig and Stoller have misinterpreted the function of the surface sculpturings. We have discussed this question in the account upon *Porcellio*. Again, Leydig, although figuring the ridges on the surface of the air tubes in the exopodite misinterprets their significance. Stoller denies their existence or at least dismisses them as wrinkles caused by collapse of the wall. In face of such serious mistakes, there is need for the whole question to be re-stated as plainly as possible, and this I have endeavoured to do.

7. *Porcellionides pruinosus* (Br.).

Pl. XIV. and XV., figs. 49-53.

Like *Porcellio scaber* this species has air-tree organs in the 1st and 2nd pairs of exopodites of the abdominal appendages, and in many ways is similar to *P. scaber*, but the abdomen is narrow, and it is much more delicate in build. It bears the same relationship to *P. scaber* as *Ph. muscorum* does to *O. asellus*.

Fig. 49 gives a ventral view of the abdomen of the female, the general arrangement of the appendages is normal. The exopodites are more curved in these narrow-abdomen forms. This may make up, in some way, for the lack of width in the abdomen. The mass of appendages together form a distinct rounded lump, instead of lying flat as they usually do.

The 3rd Abdominal Appendage: In Fig. 52 the left appendage is drawn seen from the ventral aspect. The parts are fairly typical. Protopodite, exopodite, and endopodite are all indicated. The protopodite stands well out from the ventral surface, this is shown in Fig. 53, which represents a longitudinal section through the abdomen and appendages. The exopodite fulfils the requirements of an operculum, fitting over the endopodite, and having a distinct ridge on the inner or dorsal surface, acting as a boundary to the endopodite cavity on the outer side. This ridge, which runs posteriorly from the place of articulation, can be seen through the exopodite in Fig. 52.

PORCELLIONIDES PRUINOSUS . ♀.

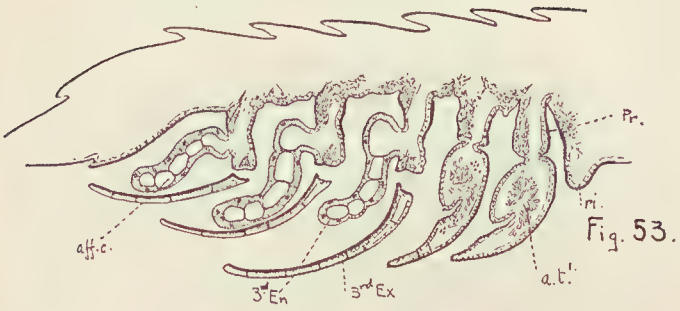


Fig. 53.

ARMADILLIDIUM VULGARE . ♀.

Fig. 54.

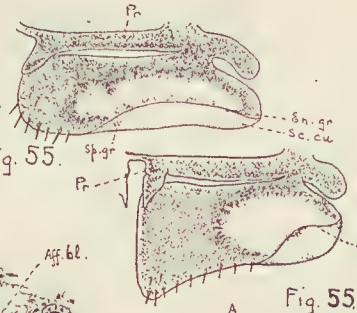


Fig. 55.

Fig. 55A.

Fig. 57.

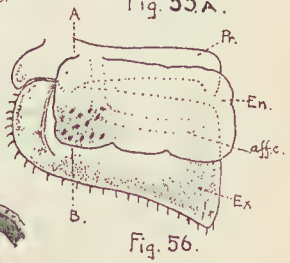


Fig. 56.

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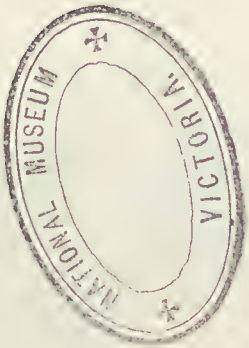
Porcellionides pruinosus ♀.

Armadillidium vulgare ♂.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The Exopodite: The structure of this exopodite seen as a flat object, and in transverse section, indicates a better blood supply than the corresponding exopodite of *P. scaber*. This is confirmed by observations upon the living creature; but the blood supply is not very good, not nearly so abundant or so vigorous as in the corresponding exopodite of *O. asellus*. The internal structure seen in section shows a wider blood cavity and better developed pillars than in *P. scaber*. The chitinous cuticle of the dorsal or inner wall is much thicker than that of the ventral or outer wall. The outer and posterior margin carries a row of short, stiff, spinous hairs, the inner margin, in its distal region, is covered wth fine hairs.

The Endopodite: This is in every way similar to the endopodites of *P. scaber*. It has a similar afferent canal, similar epithelial layer with large nuclei and well-developed pillars. (Fig. 53.)

The Exopodites of the 1st and 2nd Abdominal Appendages: These exopodites carry the "corpora alba"—the air-tree organs, the shape of the joint and the organs is shown in Figs. 50 and 51.

When the living specimen was under observation it was very evident that a much greater blood supply went to these exopodites than to the remaining normal exopodites.

The air-tree organs are of the same kind as in *P. scaber*. We notice a similar entrance groove, with the surface of the cuticle in that region sculptured; the internal structure of the tree and of the fine branches is the same; the blood supply is essentially the same also. So that all that has been written and figured for *P. scaber* will apply here.

This woodlouse has the same habit of flexing the abdomen, and of holding itself rigid in a flexed condition in very much the same way as *P. scaber*, when danger threatens. There is a very prominent ridge in front of the exopodites of the 1st abdominal appendage, and the methods in use for changing the air in these air-tree organs is exactly the same as described in *P. scaber* or *C. convexus*.

8. *Armadillidium vulgare* (Latr.).

Pl. XV., figs. 54-57.

The number and arrangement of the abdominal appendages in this species is the same as in the other woodlice, their arrangement, seen from the ventral aspect, is shown in

Fig. 54. This figure shows the shallow cavity, semi-circular in outline, which is formed by the flattening and bending down of the lateral plates of the abdominal segments and the blunt uropods. We saw something of this in *C. convexus*, but it is carried much further here.

There are large air-tree organs in the exopodites of the 1st two pairs of abdominal appendages. This species is stoutly built, the cuticle is thick and the chitin is impregnated with lime to a greater extent than in the other genera. The muscular system of the body is well developed.

The 3rd Abdominal Appendage: There are no unusual features about this appendage; it is very similar to the corresponding appendage in *P. scaber*. Fig. 56 gives a dorsal view of this appendage removed from the body, seen as a transparent object.

The Exopodite: The exopodite of this appendage and also of the 4th and 5th abdominal appendages, is little more than an operculum. In this it also resembles the exopodite of the corresponding appendage of *P. scaber*, but little blood can be seen traversing the blood cavities in the exopodite; and although the ventral or outer wall is much thinner than the dorsal or inner wall, and the exopodite more or less adapted for respiration, yet the same thing, already described in *P. scaber*, has taken place here, and, except at the period of manufacturing a new cuticle, the blood supply is much reduced. This will allow more blood to become available for the more important exopodites of the first and second abdominal appendages which contain the special breathing organs.

Sections through these appendages confirm this observation. The blood cavity in the exopodite of the 3rd abdominal appendage is seen to be much reduced, and a quantity of intermediary tissue—the tissue of the body cavity—is continued into the proximal region of the exopodite, not as a blood directing tissue, but as an obstructing tissue. In Fig. 57, which represents a longitudinal section through the first three abdominal appendages, the 3rd appendage is seen in section taken along a line represented by AB in Fig. 56. The whole length of the exopodite is not shown, but sufficient to show the details of the dorsal and ventral lamellæ with the thick cuticle on the dorsal side and thin on the ventral. The epithelial layers, the intermediary tissue and the reduced blood cavity, are also indicated. The section passes through the protopodite, and the elevator muscle is

seen, which moves the appendage for the breathing action. There is a thick ridge of chitin on the anterior surface of this protopodite; a similar ridge, but broader, is found in the corresponding position on the next protopodite, the 4th abdominal. These thick bands of chitin may have some function in connection with the power of rolling and unrolling.

The Endopodite: The endopodite is in every way similar in structure to that described under *P. scaber*. It lies in a cavity bounded by the exopodites, protopodites, and ventral body-wall. It is a cavity but little bigger than the endopodite under normal conditions. In this cavity the endopodite remains in a moist condition covered by a film of water. The boundary walls, viz., the surface of exopodites and ventral body wall, are also damp. If a living specimen is kept under observation under conditions already described on p. 15, the air is seen gradually to work its way under the exopodites as the moisture evaporates in the heat of the table lamp.

The details of structure need only to be enumerated, for they are very similar in essentials to those described in connection with the endopodite of *P. scaber*. The thin cuticle, the spongy epithelial layers, the pillars, the blood cavity, and the special afferent blood channel are all similar. The only difference is in the size of the nuclei of the epithelial layers. They are much smaller in this species than in *P. scaber* or *O. asellus*. Some of these details can be seen in the longitudinal section, but the line of the section AB does not pass through the afferent canal. (Fig. 57.)

The protection of the endopodite by the closely fitting exopodites which reaches an extreme development in this species is related to its power of living in a very dry environment.

The Exopodites of the 1st and 2nd Abdominal Appendages: These exopodites carry air-tree organs, and there is no need to describe them in detail. Figs. 55, 55a show the appendages, as they appear from the dorsal aspect as opaque objects. The air-trees are well developed, and there is the sculptured chitin in the region of the apertures of the air-trees as we have described and figured in *P. scaber*. The air-tree of the 1st abdominal segment is well developed, occupying quite three-quarters of the available space, and it seems composed of several trees with several openings in the main transverse entrance groove. The character of the tree resembles those of *Porcellio* and not those of *Cylisticus*, that is to say, the tree is composed of a large number of

branched and interlocking tubes leading off from a main stem. The air-tree nearest the inner border has a special grooved opening which runs in the sculptured face of the dorsal wall opening in a pore not far from the dorso-posterior margin. (Fig. 55.) This groove is similar, in every respect, to the grooves described and figured in the account of *Cylisticus*. There will be no need to repeat here what has already been written as to the structure of the air-tubes, the sculptured wall, the blood supply, and other details of these organs. I have examined and experimented with these air-tree organs in the same way as with those of *P. scaber*, and there are no important differences, apart from the size, the presence of more air-tree organs in one exopodite and the larger entrance groove with several separate passages into the organs.

I have also considered again the question of the changing of the air in these air-tree organs, and the conclusions come to in connection with *Porcellio* and *Cylisticus* are confirmed here. The method of bringing pressure to bear upon these swollen exopodites by flexing the body is very obvious here. In Fig. 57, which represents a longitudinal section through these exopodites, the curious ridge or process can be seen almost touching the outer or ventral surface of the exopodite of the first abdominal appendage. This specimen is only slightly flexed, and it is clear that if the abdomen is still further flexed, pressure will be exerted upon the air-tree holding exopodites. This pressure will drive the air out of the air-tubes, and when the pressure is relaxed by the straightening of the abdomen fresh air will rush into the open air-tubes. The ridges on the air-tube walls cause them to spring open and suck in the air.

The exopodites of the 5th abdominal appendage show on the dorsal surface the transverse ridge of hairs. This ridge is on the surface just behind the limits of the endopodite, and seems connected with the protection of the endopodite. All the exopodites are more hairy than in the other genera. Those of the 3rd, 4th, and 5th appendages have a row of stiff setæ extending along the outer and posterior borders.

9. *Platyarthrus hoffmannseggii* (Br.).

Pl. XVI., figs. 58-62.

If the living creature is examined it is seen that this species resembles *Trichoniscus pusillus* in the structure and function of the respiratory organs. Blood corpuscles can be

PLATYARTHRUS HOFFMANNSEGGII. ♀.

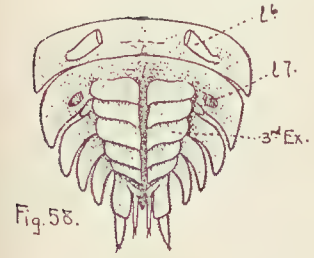


Fig. 58.

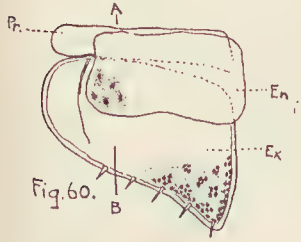
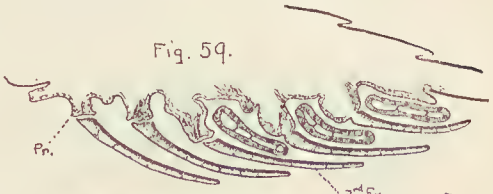


Fig. 60.

Fig. 59.



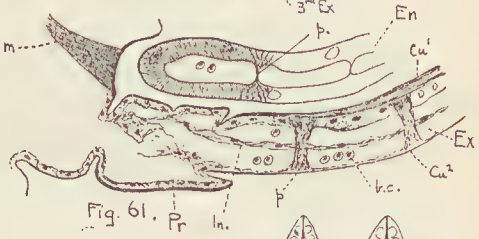


Fig. 61.

Fig. 62.

LIGIA OCEANICA ♀

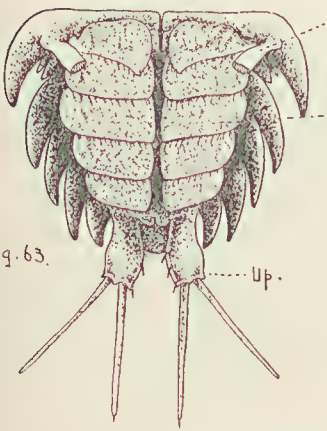


Fig. 63.

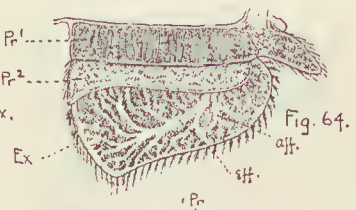


Fig. 64.

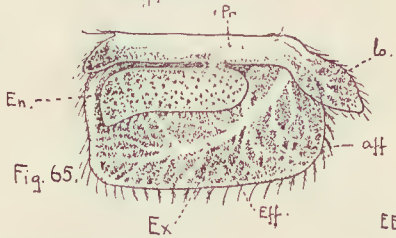


Fig. 65.

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Platyarthrus hoffmannseggii ♀.

Ligia occanica ♀.

seen traversing the blood spaces in the exopodites of all five pairs of abdominal appendages.

There is the same respiratory movement of the exopodites and alternate separation and closing of these plates to allow air to have access to the underlying endopodites. As in the other woodlice the endopodites and all the undersurfaces of the exopodites are damp with a covering film of water. This film of water is seen retreating and advancing when the respiratory movements are watched in an inverted specimen. There are no additional respiratory organs in this form; nothing in the nature of air-trees or the special organs found in *O. asellus* and *P. muscorum*.

The 3rd Abdominal Appendage: This is typical with protopodite, exopodite, and endopodite all of usual form. Fig. 60 represents one of these appendages seen from the dorsal aspect. The same appendage is seen in part as it appears in longitudinal section (Fig. 61). The detailed description follows below.

The Exopodite: This is of the usual form. It is devoid of the curious tubercles, which are scattered more or less thickly over the surface of the cuticle in other parts of the body, and which are such a characteristic feature of this woodlouse. The posterior border carries five or six large, pointed bristles.

Examined as a transparent object after treatment with methylene blue one can see that there are wide blood spaces in which blood corpuscles are found. These blood spaces run between the pillars, which are well formed and abundant. The nuclei of the epithelial layer are also prominent. The circulation as seen in the living specimen is much the same as in *Trichoniscus*. The blood enters the exopodite at the point of articulation with the protopodite, and travels towards the inner border. From here it passes down and across the expodite to find its way out through the efferent canal which runs along the outer border.

The transverse and longitudinal sections confirm these observations, and supply further details. From dorsal to ventral one finds a thick cuticle, a thick layer of cuticular epithelium, a wide blood cavity, a very thin layer of epithelium, almost nothing in places, and a very thin cuticle. Joining the cuticles together are the pillars, and if the section passes through the proximal part of the exopodite, near to the articulation, some intermediary tissue will be

found. These points are all shown in Fig. 61. All these details help to make the resemblance to *T. pusillus* still more marked.

The Endopodite: This also is very similar to the endopodites of *Trichoniscus* and *Oniscus*. It is a flat, thick walled sac. The wall is composed of a thick, epithelial layer, with large nuclei, carrying a very thin chitinous cuticle on the surface. A few pillars of the normal type join the epithelium of one side to that of the other. These pillars are very similar to those in the endopodites of *Asellus aquaticus*, which are described in great detail by Kimus in the memoir already mentioned. The pillar really consists of a number of long threads which run from cuticle to cuticle. The narrow part between the two lamellæ consists of the bundle of threads which separate fanwise in each epithelium. The threads mark out a pattern rather like an hour glass in shape or like two cones applied apex to apex.

There is no need to refer to the 1st and 2nd abdominal appendages, for the exopodites of these appendages are similar in every particular to those of the 3rd appendage, which has been described.

I have referred already to the curious tubercles that are present on the surface of the cuticle of the body and limbs. These tubercles are scattered over the dorsal surface in fair profusion and less thickly on the ventral surface. They are especially evident on the edges of the lateral plates and on the dorsal posterior edges of the thoracic and abdominal segments. They give a toothed appearance to these edges. Each tubercle is a flattened scale-like body, not standing out at right angles to the surface of the cuticle, but bent posteriorly at a small angle, so that when the carapace is examined under the microscope, one sees the tubercle almost as a flat object. Its appearance in this position is shown in Fig. 62. There appears to be a central part in the shape of a cone drawn out to a fine point with a surrounding border consisting of an expanded vacuolated wall. There seems to be a canal down the middle of the tubercle or at least some connection with the threadlike extension of the cone. The surface of the cuticle has a characteristic marking, being covered by a pattern of hollows sculptured out of the thickness of the chitin. The absence of pigment and the presence of these tubercles and the sculptured cuticle are responsible for the characteristic white colour of this woodlouse, which is blind and lives as a "pet" in ants' nests.

10. *Ligia oceanica* (Linn.)

Pl. XVI., Figs. 63-65.

Pl. XVII., Figs. 66-71.

The Abdominal Appendages: At first sight it seems that the number and arrangement of the abdominal appendages are the same as in the other woodlice. Fig. 63 shows the five pairs of plate-like exopodites overlapping in the usual manner; but upon examination it is found that the 1st and 2nd appendages still retain some traces of endopodites or at least of inner plates in a similar place to the endopodites.

Hewitt says:—"There are five pairs of abdominal appen-
"dages or pleopoda and a terminal pair of uropoda. Each
"pleopod consists of a pear-shaped superior lobe covering a
"small inferior lamella."

I agree insofar as the 3rd, 4th, and 5th appendages are concerned. The 2nd appendage carries a very small endopodite, but I can find no trace of an endopodite in the 1st abdominal appendage, although the basal part of the appendage, the protopodite to which the exopodite is attached, is large and is divided into two well-defined parts. A full description of these appendages will be given later, after the more normal appendage has been considered.

Observations upon the living creatures confirm Hewitt's short account of the course of the circulation in the exopodites, but his description is too general to be of any value. I, therefore, add a description as seen when the living *Ligia* is observed with the abdominal plates in view.

The blood enters the exopodite at the place of articulation with the protopodite and travels in a wide vessel along the anterior and inner borders.

Branches are given off from this afferent branchial vessel as it passes along the anterior border and down the inner border. These branches subdivide and disappear in the maze of interlocking vessels. There are two other main afferent vessels, distributing blood to the ventral surface: the one, arising from the principal afferent vessel near its proximal end at the place of articulation, passes backward

I am retaining the terms used throughout, namely, ventral or outer for the surface, which is obviously ventral, as the plates are found, and as they are shown in Fig. 63. Hewitt uses the term "anterior" for this face; strictly speaking it may be anterior, but with the plates lying almost horizontal, the terms ventral and dorsal seem more suitable here, and I have also used anterior, posterior, inner and outer borders to denote the boundaries of the plates regarding them as they appear *in situ*.

across the middle of the exopodite, giving off branches which subdivide still further as they approach the posterior border; the other, a smaller vessel, has a similar course nearer to the outer border. These afferent vessels are plainly nearer to the ventral surface than the other vessls which cross under them. The blood is returned from the exopodite in a system of efferent vessels which, as we have noted, are more dorsal in position, and they open into a large, very prominent efferent vessel, which runs diagonally across the exopodite from the inner posterior corner to the place of articulation. This course of the circulation is substantially the same in all the five pairs of exopodites, Figs. 64, 65, and 66. This feature of the exopodites, the presence of distinct vessels which are plainly visible to the naked eye, is unique among the woodlice.

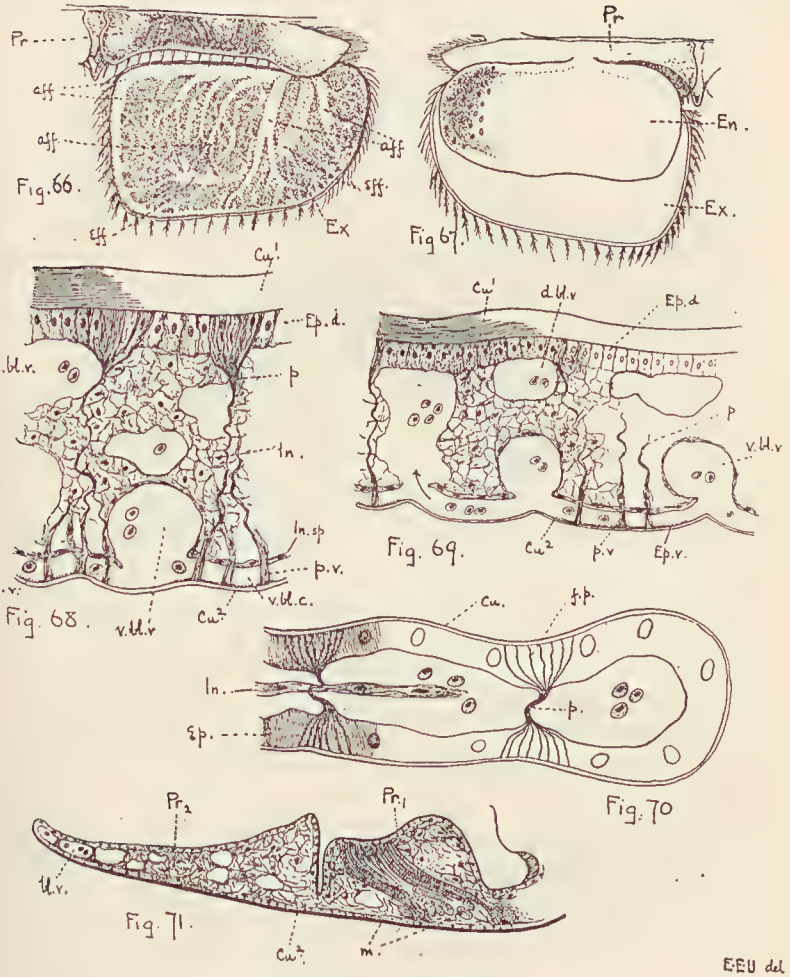
The same respiratory movements of the appendages are seen here as in the other genera described. Also the endopodites and the exopodites are damp, indeed this form gives me the impression of being able to retain a great deal of moisture under the exopodites. No doubt the presence of salt may help in this. The exopodites, besides being intersected by blood vessels and, as we shall see, respiratory in function, act as opercula to the more delicate endopodites, and the dorsal surface is curved in such a way as to enable the exopodite to fit down over the endopodite, and a transverse ridge on the dorsal surface will help to close the cavity in which the endopodite is enclosed.

It will be best to follow the plan which has been adopted in the other species and describe in detail the third abdominal appendage, and then deal with the differences found in other abdominal appendages.

The 3rd Abdominal Appendage: This is the largest of all the abdominal appendages. It consists of the three parts: a small horizontal basal part, the protopodite; an outer plate, the exopodite; and an inner plate of smaller size, the endopodite. The shape and general structure will be seen best by examining Figs. 66 and 67, which represent the left appendage seen from both ventral and dorsal aspects. The protopodite is not very different from the protopodite of many of the woodlice (see various figures). The posterior border is fringed with long, spinose bristles and the lateral extension which is somewhat leaflike in outline is fringed with fine hairs.

The Exopodite: The shape and the fringe of feathered bristles are seen in Fig. 66 in which an attempt has been

LIGIA OCEANICA. ♀.



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Ligia oceanica ♀.

made to show the characteristic appearance of the exopodite when seen either by transmitted or reflected light. The surface is covered by large and small blood vessels, which interdigitate all over the surface, and if the exopodite is treated with methylene blue it is possible to trace with considerable accuracy the afferent and the efferent vessels. There is no need to repeat here what has already been written about the circulation, but in such a preparation of the exopodite one can see plainly the more ventral position of the afferent vessels. One can see them pass on the ventral side of the efferent vessels. By careful focusing one can pass from one wall to the other inspecting the various tissues which lie between the two cuticles. It is clear that the blood vessels on the ventral or outer surface have a different external wall from the vessels near the dorsal surface. The dorsal blood vessels are examined through a thick cuticle and a very uniform layer of epithelium. One can see the regular pattern formed by the nuclei of this layer; whereas the ventral blood vessels can be seen to have a very thin and clear wall, in most cases merely a thin cuticle, or if any epithelium extremely thin and without nuclei. Blood corpuscles can be seen with great clearness lying in small cavities just under the cuticle. The cavities are marked off by what appear to be the ends of pillars, in which nuclei can be seen. If the middle part of the exopodite is examined, a mass of intermediary tissue can be seen filling the exopodite save for the blood vessels.

The cavity of the exopodite, which, in most of the other genera, is a simple blood cavity between the dorsal and ventral epithelial layers, is here invaded by a large quantity of this tissue—very like the body cavity tissue—which has nothing to do with the cuticular epithelium—and which forms the boundary walls of the numerous blood vessels.

Further information is obtained by examining serial sections through this appendage. It is abundantly evident when we examine a section of the exopodite (Figs. 68 and 69), that the ventral surface is adapted for respiratory purposes, for bringing the blood into such a position that only a very thin wall separates it from the air.

The dorsal wall consists of a thick cuticle and a layer of epithelial cells, which are uniform in size, in appearance something like a shallow palisade tissue. The nuclei of this layer are of a good size, and the whole layer is a well formed tissue.

The ventral wall is very different. There is a very thin cuticle, about one-tenth of the thickness of the dorsal cuticle. The epithelial layer is very poorly developed, indeed it is extremely difficult to make out, except in the neighbourhood of the pillars, the ventral ends of which are attached to the cuticle.

The intermediary tissue is remarkable in its great development here. In the exopodites of the woodlice already examined there is very little intermediary tissue. *Oniscus asellus* is the only one in which much is found; in the majority it is restricted to the proximal region in the part near to the place of articulation. Here, however, the exopodite is packed with the tissue. Most of it is like a ground tissue, loose stringy cells with nuclei scattered about. It is obviously a filling-up tissue, and in this it resembles the tissue found in the body cavity. It forms the boundary walls for the blood vessels, and is of great importance in connection with the circulation. The cells are not full of protoplasm, they do not stain deeply, but are rather vacuolated. The nuclei are rather smaller than the nuclei of the dorsal cuticular epithelium.

The tissue is more compact where it forms the wall of a blood vessel, and there is a distinct layer of more compact cells, forming a well defined and constant layer running parallel to the ventral wall a little distance from it. The cells of this layer are more elongated, and the nuclei seem longer also. The effect of this layer is to form a narrow blood cavity all over the ventral surface, just within the very thin cuticle. This cavity is interrupted by the ventral ends of the pillars, so that in the transverse sections the appearance is of a number of cavities side by side. (Figs. 68 and 69.)

The importance of this arrangement of the tissue is obvious, when the respiratory function of the exopodites is remembered. The ventral surface is the surface in contact with the air, the cuticle is thin, there is little or no epithelium, so that with the blood flowing in these cavities the conditions for effective respiration are fulfilled. Thus, the whole ventral surface becomes adapted for the interchange of gases between the blood and air. The width of this blood cavity is such that the blood will travel slowly, and so help in the more efficient interchange. These blood cavities, just beneath the thin cuticle traversed by the pillars, remind one of the

arrangement found in the special respiratory organs on the outer border of the exopodites of *O. asellus*.

The study of transverse and longitudinal sections enables one to carry further the description of the circulation in these exopodites. Dorsal blood vessels from their position and arrangement are little more than conducting vessels belonging to the efferent system already outlined. They are bounded by the thick dorsal wall on the one side and the intermediary tissue on the other. The ventral vessels show very clearly the connections between them and the special cavity of the ventral wall, and here and there the sections show the passage from this ventral cavity to the dorsal system of vessels. So that the blood entering the exopodite is distributed by means of the ventral afferent vessels to the special respiratory cavities which lie just within the ventral cuticle, and then travels from these cavities into the dorsal efferent vessels and so out of the exopodite. (Pl. XVII., Figs. 69 and 66.)

The pillars have already been mentioned, but a rather fuller account of them must be given, for they are rather different from the pillars found in the exopodites of the other genera in the *Oniscoidea*.

A casual inspection of a section through the exopodite might miss the pillars, for the presence of so much intermediary tissue makes them less distinct, but inspection of the ventral wall gives the first clue to their presence, and with care they can be traced across the exopodite from cuticle to cuticle.

If we start from the dorsal wall, the pillar fibres arise from 2 or 3 epithelial cells, to judge by the nuclei, and the fibres which are widely separated to start with run together into narrow bundle. The dorsal part of the pillar has, therefore, a fanlike arrangement of the fibres. The central part of the pillar is in the form of this twisted rope or bundle of fibres which threads its way through the mass of intermediary tissue, to again spread out as the ventral surface is approached. The ventral part of the pillar is, however, very different from the dorsal, the individual fibres do not separate into a fan, but into three or four groups of fibres which, pushing through the special layer of the intermediary tissue, cross the special blood cavity and fasten on to the ventral cuticle. These smaller bundles possibly represent the remains of the ventral cuticular epithelium, for nuclei can be seen in them, and it is what one would expect considering

the formation of the pillars as worked out by Kimus in the aquatic isopods. Although I have given a description passing from one side to the other, the pillar is really formed of cells from each wall, which meet and fuse in the middle.

I have attempted to draw two of these pillars as they appear in a section through the appendage (Pl. XVII., Fig. 68).

The Endopodite: The endopodite need not detain us long, for it is very similar to the endopodites of *Trichoniscus* and *Oniscus*. The general form and size as compared with the exopodite can be seen in Fig. 67. Fig. 70 shows the endopodite in transverse section. The thin cuticle, the thick epithelium, the pillars arising from the conical lumps, with their fibres spreading fanwise before becoming attached to the cuticle on either side, are all typical. If the section passes through the proximal region of the endopodite, especially near the place of articulation with the protopodite, a thin layer of intermediary tissue will be found, acting as a tissue directing the flow of blood into or out of the endopodite.

The 1st and 2nd Abdominal Appendages: These appendages need some further description, for not only do they differ from Hewitt's description, but they also differ from the general plan found in the other members of this suborder *Oniscoidea*. We have seen that the woodlice already described in this investigation have lost the inner segments or endopodites of these first two abdominal appendages. *L. oceanica* still retains traces of these inner segments.

The 1st Abdominal Segment: When the abdomen of *Ligia* is examined under the simple microscope and the exopodite of the first appendage is lifted up by a needle, a prominent ridgelike inner segment is seen. By moving the exopodite to and fro, it is clear that the exopodite is articulated with the proximal part of this inner segment near to the outer border.

The inner segment is divided into two distinct parts by a transverse suture. The two parts are about equal in area, but are very different in appearance.

If one of these appendages is removed and examined under the microscope further details can be made out. Fig. 64 represents such an appendage seen from the dorsal side as a transparent object. The proximal part of this inner segment to which the exopodite is attached is obviously the protopodite or a part of the protopodite. The presence of a pointed lobe on the outer border of the protopodite beyond the place of the

exopodite articulation is a usual feature in the woodlice, and a similar structure can be seen in Figs. 22, 23, 51, and 55. This seems to confirm the protopodite character of this proximal part. To this is attached another lobe, which looks like a special extension of the protopodite rather than an endopodite. For one thing it is attached along the whole length of the posterior border, for another it resembles in no way an endopodite, rather it more closely resembles an exopodite, as one sees it as a flat object under the microscope. I have attempted to show the structure of the various parts of this appendage as seen in the flat, and the proximal part of this inner segment is full of muscle. The fibres can be seen through the dorsal wall. In the distal part there are blood vessels ramifying through the interior of the plate, which is packed with intermediary tissue. A fairly thick cuticle and epithelium is found on both surfaces, and the free edges are fringed with feathered bristles. Further details are obtained by taking longitudinal sections through the abdomen, and in Fig. 71 is drawn a longitudinal section through this inner section which is under consideration. The proximal part with its mass of muscle, some fibres running from the dorsal to the ventral wall, others at right angles to the section; the distal part with the blood vessels and intermediary tissue and the epithelial layer showing prominently on both walls. Considering all these points I am inclined to the opinion that this inner segment is a two segmented protopodite, and that there is no real endopodite present.

The 2nd Abdominal Appendage: The second appendage is quite different from the first. There is clearly here an endopodite, as well as protopodite and exopodite; all three parts are distinct and well defined and normal in structure. Fig. 65 gives a dorsal view of this appendage. A large exopodite with blood vessels similar to those in the exopodite of the 3rd abdominal appendage, a small endopodite, about one-third of the size that it should be if it were normal, and a protopodite to which these two plates are attached. The lobe of the outer border is here unusually large and leaflike, and has a system of blood vessels very much the same as the exopodite. The small endopodite as seen in transverse section is typical in every way.

It is interesting to find these differences in the first two pairs of abdominal appendages. The woodlice, which are established further inland, have lost the endopodites of these first two appendages. It is clear from their structure and by

comparison with aquatic forms, that the endopodites are respiratory organs for use in water, and that they are useless on land unless they can be kept very damp. The exopodites have, on the other hand, become adapted for air breathing only, and function in a drier state. The first two abdominal appendages are in a favourable position for air breathing, but unfavourable for the endopodite or gill respiration, and this may have caused the loss of these parts in most of the *Oniscoidea*. Whether this is so or not, *L. oceanica* is nearer to the aquatic types than any other member of the *Oniscoidea*, and the fact that there is no endopodite in the 1st and a small one in the 2nd abdominal appendages, helps us to bridge the gulf between marine isopods and the land isopods.

SUMMARY.

GENERAL REMARKS.

It seems best to attempt a brief summary of the main points of interest which have been brought to light in the foregoing investigations, and to give a general account of the respiration of land isopods in light of these researches.

Abdominal Appendages: We have seen that the first five pairs of abdominal appendages take some part or other in respiration. A typical appendage consists of a basal part—the protopodite, an outer plate—the exopodite, and an inner plate—the endopodite.

In *Trichoniscus*, *Oniscus*, *Philoscia*, *Porcellio*, *Porcellionides*, *Cylisticus*, *Armadillidium*, and *Platyarthrus*, the 1st and 2nd abdominal appendages have no trace of endopodite. In *Ligia* only the 1st abdominal appendage is without the endopodite, although the protopodite of this appendage is very large and divided into two distinct parts (Fig. 64). The endopodite belonging to the 2nd abdominal appendage is small, about one-third the normal size (Fig. 65).

The arrangement of the abdominal appendages is the same in all the various genera; the exopodites are ventral and external, overlapping from in front backwards and covering the endopodites as opercula. (Figs. 1, 7, 17, 19, 21, 41, etc.) Both exopodites and endopodites are respiratory in function.

The Exopodite: Normally an operculum, it has become adapted for respiration by having the ventral or outer wall extremely thin, so that the blood within the exopodite is only

separated by a very thin membrane from the air outside. In the aquatic genera if there is any difference in the walls, the ventral wall is the thicker. This is seen in the exopodites of the 3rd abdominal appendage of *Asellus*, and in all the exopodites of *Cirolana*.

The simplest form of exopodite is found in *Trichoniscus* and *Platyarthrus*, that is to say, in these genera the exopodite closely resembles the normal type seen in the aquatic isopods, except for the thickness of the ventral wall. The exopodite consists of a flattened sac in which a simple blood cavity is found between the dorsal and ventral walls, which are formed of a cuticular epithelium and a chitinous cuticle. Crossing the cavity are the pillars, epithelial structures joining the wall of one side to the wall of the other. (Figs. 6, 61.) Another tissue is found in the exopodites, although it is much less evident than in the aquatic genera. It will be seen in the protopodite and extending a short way into the exopodite as a blood directing tissue. (Figs. 4 and 61.)

Although this is the normal type of exopodite there are not many genera which retain this simple form; perhaps the nearest being the exopodites of the 3rd, 4th, and 5th abdominal appendages in *Porcellio*, *Porcellionides*, and *Armadillidium*, and the chief part of the same exopodites in *Oniscus* and *Philoscia*. In the case of the former three genera, the blood cavity is much reduced, and there is but little respiration performed by them, the reason for this is the formation of very efficient breathing organs in the exopodites of the first two abdominal appendages. These air-tree organs take over, as it were, the type of respiration performed by the exopodites as a whole, and so, although originally adapted for the purpose, these last three pairs of exopodites lose their respiratory function.

Leaving *L. oceanica* for the moment, there are two quite different ways in which the exopodites of certain genera are modified to make them more efficient respiratory organs. The one kind of special respiratory organ is found in *Oniscus* and *Philoscia*—the other kind in *Porcellio*, *Porcellionides*, *Cylisticus*, and *Armadillidium*.

The first kind is a special thin extension of the outer border of the exopodites, forming small lung chambers; the second kind is an invagination of the outer wall of the exopodite to form a branching tree of air-tubes, which have very thin walls. In the first case, the blood flows through radial passages in the thin walled plate, and the air bathes the sur-

face of the special organ: in the other, the blood within the cavity of the exopodite bathes the surface of the air tubes, which have a large opening on the posterior dorsal surface of the exopodite. In each case air is brought into intimate relation with the blood, so that only a very thin membrane separates the two media.

In *L. oceanica*, however, we meet exopodites of quite a different type. Instead of the cavity of the exopodite being a simple blood cavity crossed by the pillars, and in places divided into two parts by a plate of intermediary tissue, the cavity has been invaded by the intermediary tissue to such an extent as to confine the blood to a definite system of blood vessels, the walls of which are partly formed by the cuticular epithelium and partly by this intermediary tissue—a tissue of mesoblastic origin. There are ventral vessels, the afferent system, leading into a network of narrow cavities which cover the ventral surface and lead into dorsal vessels—the efferent system.

We have here a very different type of exopodite from any of the other members of the *Oniscoidea*, and indeed the amount of intermediary tissue is greater than in any of the aquatic forms described by Kimus. The reason for this difference seems to me to be associated with its large size and the fact of becoming terrestrial. The large exopodites of *Ligia*, especially in comparison with the genera most nearly related, e.g., *Trichoniscus* and *Ligidium*, do require an internal supporting tissue in a way that the exopodites of the others do not. The intermediary tissue is the same kind of tissue which is found performing the same kind of supporting and filling-up functions in other parts of the body. The point to notice here is that the circulation is so arranged that the blood in the exopodite is conducted to the small cavities on the ventral face where there is only a very thin cuticle separating it from the air. In this way the exopodite is adapted for respiration in air.

The Endopodite: Unlike the exopodites which exhibit considerable variation, the endopodites are practically identical in structure throughout the sub-order *Oniscoidea*. In every genus examined, the endopodite can be described as a thick walled, flattish sac containing blood. The wall is very constant in composition, being formed of a thick spongy epithelium, the cells of which are not easily distinguished except by the large nuclei. The protoplasm of the cells has much the same character in all the species—a striation

running at right angles to the surface. The epithelial layer carries thin cuticle on its outer surface, and on its inner surface is in the form of conical protuberances which join across the cavity in pairs to form the characteristic pillars. The spreading fibres of the pillars can be traced through the protoplasm to the cuticle to which they appear to adhere. The endopodites of *Asellus* are very similar. Intermediary tissue is found in the protopodite to which the endopodite is attached, and in some genera it extends a little way into the endopodite. In this case its function is similar to that of the intermediary tissue found in the proximal region of the exopodite, namely, the proper directing of the blood entering and leaving the plate.

In three of the genera examined, *Porcellio*, *Porcellionides*, and *Armadillidium*, the arrangement for the blood is rather different. A special afferent canal is formed by an alteration in the thickness of the ventral epithelial wall at one place. Instead of the thick spongy layer, one finds a narrow layer of quite small cells, rather like intermediary tissue cells, forming an arched wall in a narrow band running back from the place of articulation, tracing out, in the larger endopodites, the letter L. The details of this tube are fully described in *P. scaber*. Also see Figs. 31, 32, 53, 56.

I do not propose to discuss here the minute histological details of the various tissues of these respiratory appendages. Kimus, in his account of *Asellus* and other aquatic isopods, to which reference has been made, has described in considerable detail the histological features of tissues which are similar in every way.

I do not feel able, however, to pass over the question of the pillars and the intermediary tissue without some little attention, for some of the chief points of interest in the work of Kimus are centred around the pillars and the intermediary tissue. Taking the pillars first, it will be well to see how they compare with those found in the aquatic genera.

Kimus distinguishes several different kinds of pillars:—

"Certaines cellules épithéliales d'une face s'unissent à "des éléments de l'autre face au travers, de la cavité "branchiale pour former des piliers multicellulaires.

"Parmi ceux-ci, on en distingue de bicellulaires, formés "par l'union d'une seule cellule d'un côte avec une seule "cellule de l'autre. Cette disposition s'observa dans les "piliers de l'exopodite de la Cirolana.

"D'autres sont au contraire formés d'un plus grand "nombre d'éléments voisins appartenant à chacune des faces. "Ce sont alors des colonnes formées par la juxtaposition "de plusieurs piliers bicellulaires. Nous avons signalé cette "variété chez l'Anilocra, la Cymothoa, l'Idotea, et dans la "zone protectrice d'exopodite de l'Asellus. Une cellule "épithéliale peut contracter des rapports, non avec une cellule "de la lamelle d'en face, mais directement avec la cuticule de "cette dernière. Pour cela, elle a dû écarter certaines cellules "de la couche cuticulaire, dénuder la cuticule, et s'y fixer par "son extrémité. Ces cellules constituent des 'piliers simples' "et unicellulaires. Ici se présente aussi le cas où les piliers "sont formés par la juxtaposition de plusieurs éléments "appartenant à la même face. Ce sont alors des piliers mul-"tiples et unicellulaires. Enfin certaines cellules contractent "avec une cellule située en face des rapports plus complexes "que ceux que nous venons d'indiquer.

"Au lieu de s'abuter pars une extrémité simple avec une "extrémité semblable de la cellule opposante, elles "présentent une série de protubérances qui s'unissent "à des productions toutes semblables appartenant "à des cellules qui leur font face. Ces diverses protubér-"ances sont bien distinctes, isolées les unes des autres: le "sang circule entre elles.

"Chacune de ces cellules contribue donc à former non "pas un seul pilier, mais plusieurs. On peut leur donner le "nom de cellules multicolonnaires. Ces éléments, extrême-"ment remarquables, s'observent chez l'asellus aquaticus, "dans les lames internes (endopodites) et dans la zone "brancilale des lames externes."

The pillars found in the sub-order *Oniscoidea* are for the most part of the simpler kind. In the exopodites of *O. asellus*, *T. pusillus*, and *Platyarthrus*, "piliers simples" are found and "piliers bicellulaires" also. (Figs. 6, 13, 61.) These are very similar to the pillars figured and described by Kimus in the operculum of *Asellus* and in the exopodites of *Idotea*.

We have seen that in the genera *Porcellio*, *Cylisticus*, *Porcellionides*, and *Armadillidium* pillars are not well developed. In the exopodites which contain the air-tree organs, one or two rather prominent pillars are found joining the dorsal and central walls together around the outskirts of the air-tree organ, where the two faces come into normal relationship to one another. (Fig. 33.) These are of the

bicellular type and "multiple." The endopodites of all the genera have pillars which resemble in every way those figured and described, by Kimus, in the endopodites of *Asellus*. They are not formed of complete cells, but by the fusion of processes from the large epithelial cells—les cellules multicolonnaires. However, in most genera these cells are not so large as those found in *Asellus*, and do not carry so many pillars. (Figs. 5, 15, 16, 32, 61, 70.) The most unusual type of pillars are those found in the exopodites of *L. oceanica*. (Figs. 68, 69.) They resemble in a general way the type found in the endopodites, that is to say, radiating threads or fibres can be traced to each cuticle, but they are fundamentally different from these, for they are multicellular. Several cells on each face give rise to them. A full description has already been given of these pillars in *Ligia*.

Function of the pillars:—

1. They will prevent the too wide separation of the dorsal and ventral walls. "De longues colonettes minces comme "celles de la lame externe de l'Asellus ou des Cloportes, ne "peuvent évidemment servir qu'à limiter l'écartement des "deux lamelles." (Kimus.)

2. The more robust pillars would prevent the flattening of the plates when external pressure is applied. "L'un et "l'autre de ces mouvements exagérés doivent être "évités pour le fonctionnement regulier de l'organe. En "effet, si les deux lamelles pouvaient s'écarter librement, "l'organe tendrait à prendre une forme vésiculeuse,—c'est "une loi physique,—à la moindre perturbation qui pourrait "se produire dans le courant efférent, le canal afférent con"tinuant à déverser le sang dans l'organe. Dés lors, une "stagnation plus ou moins accusée du sang respiratoire "pourrait se produire. Si au contraire une pression "extérieure s'exerçait sur les lamelles, la cavité pourrait se "trouver complêtement effacée et la circulation branchiale "serait arrêtée. Il semble donc certain qu'en toute hypothèse "les piliers jouent ce rôle passif." (Kimus.)

3. Contractility: Kimus goes further and described the power of contractility possessed by many of the pillars. Some of the genera studied by him—*Cirolana*, *Anilocra*, and *Cymothoa*, have large and very extraordinary pillars, with a striking resemblance in structure to muscle-fibres.—"L'im "pression," he says, "qui nous reste de l'étude de tous les "piliers que nous avons examinés est que la substance des

" faisceaux délimités présente une structure plus semblable " à la structure musculaire. Qu'aucune autre production " cellulaire dont nous ayons connaissance."

Other facts are brought forward, the innervation of the pillars; direct observation of a fluttering movement in the lining branchiæ of *Asellus*, the different sizes of the internal cavity in the case of the endopodites, when seen in transverse section, and they lead up to the conclusion.—"La structure, les " réactions, l'innervation des piliers et l'observation des " organes vivants ou fixés, concourent à nous démontrer que " ces productions sont données d'une contractilité semblable à " celle des fibres musculaires.

" Il existe donc chez les édriophthalmes des cellules épithélio-musculaire."

In the *Oniscoidea* as a whole the pillars of the exopodites are not particularly well developed. They are mostly of a simple type, and not present in great numbers. Their function here seems of the passive kind preventing the collapse or the too great widening of the internal cavity. Possibly the small size of the exopodites in most genera would account for the lack of the contractile character. In the case of *Ligia occanica*, it seems feasible that the pillars in the wide exopodites will have a contractile function, for the presence of the intermediary tissue and the consequent formation of blood-vessels will do away with the dangers of collapse and over extension. Yet the pillars are quite distinct, and the fibres united into bundles "faisceaux de fibrilles" run from cuticle to cuticle. Their appearance too favours the contractile nature, and also the advantage, in promoting more efficient circulation in the ventral cavities, of the power of contractility, is obvious. I examined the ventral surface of the exopodites of a living specimen, and there did appear to be some slight movement of the surface, something to which the name "fluttering movement" might be given, but I am in doubt as to the wisdom of counting this observation as evidence, for it is difficult to be quite sure of such movements, and I may have been influenced by Kimus's account. However, I offer the observation for what it is worth. It seemed clear to me at the time.

The pillars in the endopodite certainly appear to be contractile. The chief evidence apart from structure, is the very varied size of the internal cavity, as seen in transverse section.

The Intermediary Tissue: Kimus has given this name to the tissue which is found in the cavity between the two epithelial walls of the exopodite and endopodite, and which in the proximal region of either plate is continuous with the same kind of tissue in the protopodite and in the body cavity. Its use is to direct the blood. This function will be seen illustrated in several of the Figs., especially in the exopodites which bear air-tree organs. (Figs. 34, 35, 61.) In *Oniscus* its use is still further extended. As a rule in the exopodites and endopodites its presence is restricted to the part near by the place of articulation, but in *Oniscus* it is found acting as a horizontal partition in the special breathing organs (Figs. 11, 12, 14.) *L. oceanica* is also an exception, and differs from the other *Oniscoidea* in having the exopodites packed full with this tissue. This special case has been already dealt with in the communication on *Ligia*.

Although this tissue is more prevalent in the aquatic isopods than in the terrestrial forms (except *Ligia*) there are no differences in structure to note, and reference should be made to the memoir by Kimus.

General Remarks upon Respiration: The whole problem of respiration in the terrestrial isopods is much more complicated than in their aquatic relatives. Organs adapted for absorbing oxygen that is dissolved in water, cannot easily be made to act in the air. It seems to me that the woodlice have two rather distinct methods of respiration, the one method not very different from that of the aquatic forms; the other adapted more for obtaining oxygen from ordinary air.

The obvious respiratory organs for aquatic life seem to be of the "endopodite" type, that is to say, a blood sac with a thick spongy wall composed of an epithelial layer and a thin cuticle. In *Asellus aquaticus* even the exopodites have somewhat this structure, and the same thing is found in *Anilocra* and *Cymothoa*. Kimus devotes some attention to the matter, and concludes that the thick wall of spongy protoplasm is a most efficient wall for the respiratory exchange, and that the living protoplasm plays some important part in obtaining the oxygen. He concludes by saying:—

"Le gaz qui a traversé la cuticule et pénétre dans la mass
" protoplasmatique vivante, dans ce laboratoire de la cellule
" où se produisent tant de réactions, va-t-il passer en totalité?
" Ou bien ce protoplasme ne va-t-il pas, au contraire, le
" retenis, en grande partie et former des corps, oxydés qu'il

"utilisera lui-même ou déversera peut-être dans le sang? "Rien ne prouve que l'épithélium lamellaire laisse passer tout "l'oxygène qu'il absorbe. On peux faire la même remarque "chez d'autres animaux, les vertébrés par ex. Chez les "édriophthalmes, le fait que la couche de protoplasme qui "sépare le sang du milieu extérneur est plus puissante dans "les positions qui doivent être les plus respiratoire, est une "indication sérieuse. Elle parait montrer que, chez ces "animaux au moins, le protoplasme vivant joue un rôle dans "l'absorption et l'utilisation de l'oxygéne."

Now the endopodites of woodlice are without exception of this same type—having thick spongy walls. One may conclude, therefore, that they are adapted for a similar method of respiration. How is this possible in a terrestrial habitat? We have seen how that the endopodites of all the woodlice have been found to be very damp, to be covered with a distinct film of water, and this, not only in those living in damp situations, but in the "drier" species too. And it seems clear to me that in retaining the "gill-like" character of the endopodites, the woodlice have perforce to retain a film of water around these endopodites to act as the medium for oxygen and carbonic acid gas. The layer of water will have its available oxygen constantly renewed, as the air is drawn beneath the exopodites during the breathing action, and the endopodites are then able in some way to absorb this oxygen through the medium of this film of water. Of course, this is not a very satisfactory method, and there is the great danger of "drying up"—a peril very real to all the woodlice.

The other method of respiration is an attempt to solve the problem by obtaining a very thin membrane between the blood and the air. This extreme thinness of the respiratory membrane is found in the case of the air cells in the lungs of vertebrates, and seems as important for ordinary air breathing as the thick wall was for the aquatic method.

The exopodites are adapted for this purpose. The simplest adaptation is to use the whole ventral surface as a respiratory surface. This is what we find in *Trichoniscus*, *Platyarthrus*, and in a different way in *Ligia*. That this has been, as it were, the first and simplest method is shown by the fact that in all the genera the ventral or outer wall is thinner than the dorsal. The normal arrangement is the direct reverse of this.

In the other genera of *Oniscoidea* methods are found whereby the respiratory surface is obtained in a still thinner

condition. In *Oniscus* and *Philoscia* special thin-walled border organs are found, and in *Porcellio, Porcellionides, Cylisticus,* and *Armadillidium* a much more satisfactory method has been developed in which there is much less likelihood of the danger of desiccation. This is by the formation of the air-trees, invaginations of the outer wall of the exopodite in the form of branching air-tubes. The term "lung-trees" might be used, for they are restricted in extent, and the blood plays an important part. We have here an independent attempt to solve the problem of aerial respiration in the *Arthropoda*, and in many ways it is comparable to the methods found in the *Insecta* and *Arachnida*. However, the woodlice are severely handicapped in the matter of respiration by the small size of these organs and their inability to do without the endopodites. These facts have caused the range of the woodlice to be rather limited, for they have to seek for places where conditions will be favourable for both methods of breathing.

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EXPLANATION OF PLATES.

PLATES X. TO XVII.

Abbreviations used in all figures.

Cu., cuticle.
Cu^1., cuticle of inner or dorsal wall.*
Cu^2., cuticle of outer or ventral wall.**
Ep., epithelium of wall.
In., intermediary tissue.
Pr., protopodite.
Ex., exopodite.
En., endopodite.
1st Ex., 3rd Ex., etc., exopodite of 1st or 3rd abdominal appendages, etc.
p., pillar.
b.c., blood corpuscle.
n., nucleus.
l^6, l^7, 6th of 7th walking legs, in all cases cut short or removed entirely.
up., uropods.

Other references are given under the details of each figure.

*, **. The terms "dorsal" and "ventral" are used to distinguish the two walls of the exopodite or endopodite.

"Ventral" is the obvious ventral face taking the appendage as being practically horizontal (= inferior, external, anterior).

"Dorsal" is the obvious dorsal face (= superior, internal, posterior).

PLATE X.

Trichoniscus pusillus.

Fig. 1. Ventral view of the abdomen of female. × 15.

Fig. 2. Ventral view of the 3rd abdominal appendage of left side. × 50.
aff., afferent canal running along inner border.
eff., efferent canal running along outer border.
Blood spaces between the groups of dots, which represent pillars.

Fig. 3. Dorsal view of the 3rd abdominal appendage (left). × 50.
En. lo., lobe of the endopodite.

Fig. 4. Longitudinal section through the abdomen. Semi-diagrammatic. × 75.

n.c., nerve cord.

4th Endo., endopodite of 4th abd. appendage.

This figure illustrates arrangement of exopodites, endopodites, and protopodites. Note thin *ventral* wall of exopodites.

Fig. 5. Transverse section of Endopodite (a part only shown.) × 350.

n., nucleus of the thick epithelium.

p., pillar with radiating fibres attached to the dorsal and ventral cuticle.

b.c., blood corpuscle in the blood cavity.

Fig. 6. Transverse section of Exopodite (a part only shown.) × 350.

aff., the afferent blood canal.

Ep., the epithelium of the dorsal or inner wall. The epithelial layer of ventral wall is very thin as is the ventral cuticle Cu^2.

Plate XI.

Oniscus asellus.

Fig. 7. Ventral view of abdomen of female. × 4.
The 3rd appendage of the right side is turned forward to show the protopodite and endopodite. Notice also "special breathing organs" on the outer borders of exopodites.

Fig. 8. Ventral view of 3rd abdominal appendage (endopodite omitted) of the right side. × 15.
Methylene blue treatment:
Ex^1, the ordinary part of exopodite.
Ex^2, the special respiratory part.

Fig. 9. A small part of Ex^2 of Fig. 8 more highly magnified. Radial blood cavities shown.

Fig. 10. Dorsal view of 5th abdominal appendage. × 15.
This shows the special row of hairs "like a cheval-"de-frise." Fr.

dr., the dorsal ridge marking the boundary between the two parts of the exopodite.

Figs. 11, 12, 13, 14. Illustrate details of the Exopodite seen in T.S. & L.S.

Fig. 11. The outer part of Exopodite in transverse section. × 75.
dr., the dorsal ridge as above.
bl. c., blood cavity.
In., intermediary tissue.

Fig. 12. Portion of "special respiratory organ" of Exopodite in T.S. × 100.
n., nucleus of simple epith. pillar.
In. par., intermediary tissue forming partition.

Fig. 13. The inner part of Exopodite in T.S. × 75.

Fig. 14. Longitudinal section through parts of the 1st two abd. Exopodites. × 75.
Ex^a, special respiratory part of 1st.
Ex^b, ordinary part of 2nd.
d. bl. c., dorsal blood canal.
v. bl. c., ventral blood canal.
In. par., partition of intermediary tissue.
A. ch., "air pocket" or "lung cavity." The air retained in this cavity gives the silvery appearance.

Fig. 15. Semi-diagrammatic transv. section of Endopodite.

Fig. 16. Longitudinal section through the 3rd abd. appendage. × 50. The line of section is through the place of articulation of Endopodite with Protopodite.

Plate XII.

Philoscia muscorum.

Fig. 17. Ventral view of abdomen of female. × 7.

Fig. 18. Ventral view of 3rd abdominal appendage, right side. × 15.
(Seen as a transparent object.)
Ex^2, special respiratory part of Exopodite.
En., Endopodite (shaded in to show up).

Philoscia couchii.

Fig. 19. Ventral view of abdomen of female. × 7.

Fig. 20. Ventral view of 3rd abd. appendage of left side. × 15.
Note the small size of the respiratory part.

Porcellio scaber.

Fig. 21. Ventral view of abdomen of female. × 6.
Air-tree organs in Exopodites of appendages 1 and 2.

Fig. 22. Ventral view of the 1st abdominal appendage of right side. × 18.
(Seen as an opaque object.)
The letters refer to sections represented later.

Fig. 23. Dorsal view of the 2nd abdominal appendage of right side. × 18.
(Seen as an opaque object.)
a.t., air-tree organ.
gr., the main entrance groove leading to air-tree.
sc. a., sculptured area of the cuticle.
AB, line of section Fig. 33.

Fig. 24. Ventral view of 3rd abdominal appendage of left side. × 18.
(Seen as a transparent object.)
aff. c., aff. blood canal of Endopodite shown in outline.

Fig. 25. Longitudinal section through the abdomen. × 25.
ri., transverse ridge, important in connection with exchange of air in air-trees.
a.t.^{1}, air-tree organ of 1st abd. appendage.
a.t.^{2}, air-tree organ of 2nd abd. appendage.
Fr., the "frise" of hairs.

Plate XIII.

Porcellio scaber (continued).

Fig. 26. Part of a longitudinal section of 3rd abd. appendage. × 45.
(Endopodite omitted.)
Ep^1, Epithelium of dorsal wall.
Ep^2, Epithelium of ventral wall.
} The specimen was one which had just moulted. Epithelium very distinct.

Fig. 27. Small part of Exopodite in L.S. × 45 from normal specimen. The epithelium is vacuolate, nuclei prominent; distinct inner boundary wall of tissue—(ch.); very narrow blood cavity.

Fig. 28. Small part of a longitud. section of an exopodite shortly before ecdysis. × 50.
Notice the character of cuticular epithelium, and size of blood cavity.
O. Cu^1, old cuticle of the dorsal wall.
N. Cu^1, new cuticle of the dorsal wall.
O. Cu^2, old cuticle of the ventral wall.
N. Cu^2, new cuticle of the ventral wall.

Fig. 29. Small portion of the Exopodite in the proximal region seen as a transparent object after treatment with methylene blue. The lighter patches represent the blood spaces.

Fig. 30. Dorsal view of the 3rd abdominal appendage of right side. × 18.
Methylene blue treatment.
Protopodite and Exopodite shown in outline only.

Fig. 31. Ventral surface of Endopodite (methylene blue). × 18.
aff. c., the ventral wall of afferent blood canal.
AB. line of section of Fig. 32.

Fig. 32. Longitudinal section of Endopodite (along AB in Fig. 31). × 100.
n., nucleus of epithelium, Ep.
aff. c., afferent blood canal.
v.e. aff. c., ventral wall of same.

Fig. 33. Transverse section of the 2nd abdominal Exopodite. × 35 (line of section AB in Fig. 23).
En. gr., main entrance groove.
p., pillars in the normal part of Exopodite.
Cu^2, ventral cuticle, *thick*.

Figs. 34 and 35. Longitudinal sections through the 1st abd. Exopodite taken along lines AB and CD in Fig. 22. × 35.
These figures illustrate the blood supply to the air-tree.
aff. c., afferent canal. Eff. c., Efferent canal.

Fig. 36. One of the small branches of the air-tree organ. × 100.
Note character of the wall.

Fig. 37. Portion of the outer part of the air-tree organ in L.S. × 150.
cu., cuticle of the wall of Exopodite with its epithelium (cu. ep.).

a.t.cu., cuticle of air-tube. Note the ridges on the walls.

a.t. ep., epithelium of the air-tube represented by trace of protoplasm round the nuclei and the persistent chitinous niner boundary of tissue.

bl. c., blood cavity.

Fig. 38. Small portion of the sculptured cuticle from sides of entrance groove (surface view).

Fig. 39. Similar section to that in Fig. 37 taken at a time when the new cuticle is being formed. The epithelium of air-tubes is very distinct at this time. Compare it with the epithelium in Fig. 37.

Fig. 40. Longitudinal section of 1st abdom. Exopodite taken along line EF in Fig. 22. × 75.

This shows the general structure of the Exopodite and air-tree organ.

Cu^2, thick cuticle of ventral wall.

Cu^1, thin cuticle of dorsal wall.

En. gr., entrance groove to air-tree.

Sc. cu., sculptured cuticle—the limits of this area are shown.

Plate XIV.

Cylisticus convexus.

Fig. 41. Ventral view of abdomen of female. × 7.

Fig. 42. Part of a transverse section through the abdomen in the region of the 3rd abd. appendage. × 20.

Ex., Exopodite containing air-tree organ.

En., Endopodite.

l.p., lateral plate of abdomen.

g., alimentary canal.

n.c., nerves from n. cd.

Fig. 43. Ventral view of the 3rd abdominal appendage. × 25.

(Seen as a transparent object.)

Fig. 44. Dorsal view of the outer part of Exopodite. × 25.

En. gr., main entrance groove to air-tree.

s.g., special entrance groove.

Fig. 45. Transverse section through the Exopodite (along AB in Fig. 44). × 75.

En. gr., main entrance groove.

Fig. 46. Transverse section of same passing through a special entrance groove. × 75.

[Only a portion of the sections drawn in Figs. 45 and 46.]

Fig. 47. One of the special entrance grooves seen as a transparent object, with the air retained within. × 100. The shallow sculpturing of the surface cuticle is shown.

Fig. 48. Small portion of wall of air-tree organ showing the ridge markings. × 75.

Porcellionides pruinosus.

Fig. 49. Ventral view of the abdomen of female. × 12.

Fig. 50. Dorsal view of the 1st abdominal appendage of left side. × 35.

Fig. 51. Dorsal view of the 2nd abdominal appendage of left side. × 35.

(Both seen as opaque objects.)

Fig. 52. Ventral view of the 3rd abdominal appendage of left side. × 35.

(Seen as a transparent object.)

Plate XV.

Porcellionides pruinosus (continued).

Fig. 53. Longitudinal section through the abdomen. × 35.

a.t.[1], air-tree organ of 1st abd. appendage.
aff.c., afferent blood canal of Endopodite.
ri., ridge for pressure on air-tree for expiration.

Armadillidium vulgare.

Fig. 54. Ventral view of the abdomen of female. × 5.

Fig. 55. Dorsal view of the 1st abd. appendage of right side. × 12.

(Seen as an opaque object.)
En. gr., main entrance groove.
Sc. cu., sculptured cuticle.
Sp gr., special entrance groove.

Fig. 55a. Dorsal view of the 2nd abd. appendage of right side. × 12.

(Seen as an opaque object.)

Fig. 56. Dorsal view of the 3rd abd. appendage of left side. × 12.

(Seen as a transparent object.)
Underlying parts (e.g., aff.c., the afferent canal of Endopodite) shown by a broken line.

Fig. 57. Part of a longitudinal section through the abdomen. × 25.
Only the details of the first three appendages are shown.
ri., transverse ridge.
Aff. bl., afferent blood canal passing through the protopodite bounded by intermediary tissue.
Sc. cu., sculptured cuticle. The limits of this can be seen.

The section of the 3rd appendage passed through the place of articulation of the exopodite and protopodite. The endopodite, therefore, does not show the afferent canal in section. See AB in Fig. 56 for line of section.

Plate XVI.

Platyarthrus hoffmannseggii.

Fig. 58. Ventral view of the abdomen of female. × 15.

Fig. 59. Longitudinal section through the abdomen. × 45. Arrangement of appendages and parts as in the other sections of similar kind.

Fig. 60. Dorsal view of the 3rd abdominal appendage of left side. × 50.
(Seen as transparent object.)

Fig. 61. Part of a longitudinal section of the third abdominal appendage such as along the line AB in Fig. 60. × 150.

Fig. 62. Two tubercles from edge of telson. They are drawn as they appear from above, as transparent objects. The figure also shows the cuticle with its shallow polygonal cavities.

Ligia oceanica.

Fig. 63. Ventral view of abdomen of female. × 3.

Fig. 64. Dorsal view of 1st abdominal appendage of right side. × 7.
(Seen as transparent object.)
Pr^1, proximal division of Protopodite showing the muscles within.
Pr^2, distal division of same containing blood vessels.
Ex., Exopodite showing afferent (aff.) and efferent (eff.) vessels.

Fig. 65. Dorsal view of 2nd abdominal appendage of right side. × 7.

Pr., Protopodite with large outer lobe, lo.
En., Endopodite.
Ex., Exopodite with afferent and efferent vessels.

Plate XVII.

Ligia oceanica (continued).

Fig. 66. Ventral view of 3rd abd. appendage of left side. × 7.

(As transparent object with Endopodite omitted.)
The Exopodite shows the circulation.
aff., the afferent vessels, ventral.
eff., the efferent vessels, dorsal.

Fig. 67. Dorsal view of the 3rd abd. appendage of left side. × 7.

Exopodite shown in outline.
Endopodite with small portion showing details.

Fig. 68. Transvere section of the 3rd Exopodite. Only a small part shown, to illustrate the pillars. × 150.

d. bl. v., dorsal blood vessels (efferent system).
v. bl. v., ventral blood vessels (afferent system).
v. bl. c., special ventral blood cavity for respiratory purposes.
Ep. d., Ep. v., epithelium of dorsal and ventral walls.
In., intermediary tissue.
In. sp., special layer of this tissue.
p., pillar. p.v., ventral termination of pillar.

Fig. 69. Another part of an Exopodite in T.S. × 100.

References as in Fig. 68.
Here the connection between the ventral cavities and the afferent and efferent systems is shown.

Fig. 70. Part of a transverse section of an Endopodite. × 100.

p., pillar; f.p., fibres of pillar attached to cuticle.

Fig. 71. Longitudinal section through the protopodite of the 1st abd. appendage. × 50.

Pr^1, Pr^2, the two parts of Protopodite.
bl. v., blood vessel.

A CONTRIBUTION TO THE ORCHIDOLOGY OF TASMANIA.

By
R. S. Rogers, M.A., M.D., F.L.S.

(Read 14th September, 1931.)

Caladenia longii, Rogers.

Planta gracillima, leviter hirsuta, circa 6.5—15 cm. alta, basi vagina cylindracea membranacea. Folium imperfectum, fere glabrum, longiusculum, angustum, lineare. Caulis gracillimus, paulo infra medium bractea subulata. Flores 1-3, albi vel carnei (?), circiter 2-2.8 cm. in diametro; pedicelli longiusculi, graciles, basi bractea angusta acuta; ovarium angustum, elongatum, glanduloso-hirsutum. Segmenta perianthii subsimilia, extrinsecus glandulosa-hirtella fuscioraque; sepala lateralia elliptica, acuta, patentia, circa 1.2—1.5 cm. longa, 4 mm. lata, 5-7-nervia; sepalum dorsale incurvum, leviter concavum, circa 1.1—1.2 cm. longum, 3 mm. latum, subacutum, lanceolatum; petala falco-elliptica, acuta, 5-nervia, patentia, circa 1.1—1.2 cm. longa, circa 2.5 mm. lata. Labellum unguiculatum, columnam fere aequans, transverse vittatum, 3-lobatum; lobi laterales magni rotundati integri vel a fronte leviter incisi, lobus intermedius triangularis recurvus marginibus pectinatis vel denticulatis; calli 4-seriati, obstipi, anticis brevioribus. Columna erecto-incurvata, superne latiuscule alata, transverse vittata. Anthera breviter mucronata.

Slightly hairy, very slender, about 6.5—15 cm. high, a cylindrical sheath at the base. The leaf incomplete in my specimens, narrow linear, almost glabrous, apparently rather long. Flowers 1-3; pedicels slender, rather long, subtended by a narrow acute bract. Segments of perianth somewhat similar, dusky and glandular—hairy on the outer side; lateral sepals spreading, elliptical, acute, about 1.2—1.5 cm. long, 4 mm. wide, 5-7-veined; dorsal sepal erecto-incurved, slightly concave, about 1.1—1.2 cm. long, 3 mm. wide, subacute, lanceolate; petals falco-elliptical, acute, spreading, 5-nerved, about 1.1—1.2 cm. long, 2.5 mm. wide. Labellum clawed, nearly equal in length to the column, transversely barred, 3-lobed; lateral lobes large rounded entire or slightly notched anteriorly, middle lobe triangular recurved with pectinate or denticulate margins; calli in 4 rows, linear, bent, becoming shorter towards the apex. Column erecto-incurved, rather widely winged above, transversely barred. Anther shortly mucronate.

Tasmania. Railton Hills, North-West Coast. Mr. F. H. Long, 22-10-30.

The flowers are described by Mr. L. Rodway as "pink " to white tinged with red," but when received by me in the dried state they were whitish suffused with violet in the case of one plant and of a deep violet colour in the case of the others.

It belongs to the section *Eu-Caladenia*, and in particular it is related to those members of the section which group themselves around *C. carnea*, R. Br.

The chief characteristics of the new species are to be found in the narrow linear leaf; in the prominent almost entire lateral lobes of the labellum, and in the bent non-clavate linear calli which are arranged in four rows.

The lateral lobes of the labellum readily distinguish it from the *C. testacea* group in which these lobes are ill-defined. Here may be included *C. testacea*, R. Br., *C. angustata*, Lindl., *C. hildæ*, Nicholls, *C. dimorpha*, Fitzg., *C. præcox*, Nicholls. The same character separates it from *C. deformis*, R. Br., and to a lesser extent from *C. cucullata*, Fitzg. The latter has also a very different intermediate lobe with crenate margins and differently shaped calli.

The shape and arrangement of the calli serve to differentiate it from *C. carnea*, R. Br., and its variety (*C. carnea*, var. *aurantiaca*, Rogers) as well as from *C. cærulea*, R. Br. and *C. saccharata*, Rchb. f., in all of which the calli are arranged in two rows on very slender pedicels surmounted by conspicuous globular apices.

The much smaller flowers of *C. iridescens*, Rogers, with their dusky red colour mingled with iridescent golden tints and a middle lobe of the labellum bordered with long clavate glandular calli, are not likely to be mistaken for those of the new species.

In the case of *C. alpina*, Rogers, the broad leaf of the plant and ill-defined lateral lobes of the labellum afford at once a means of separation.

C. atkinsonii, Rodway, may possibly prove to be an abnormal form. Under any circumstances its very characteristic labellum which is devoid of calli should easily separate it from *C. longii*, Rogers.

With the two Western Australian species *C. paniculata*, Fitzg., and *C. purdieana*, Andrews, no confusion should arise, as both these plants possess paniculate inflorescences as well as marked structural differences in the flowers.

HYMENOPHYLLUM MINIMUM, A. Rich.

By

L. Rodway, C.M.G.

(Read 12th October, 1931.)

This rare little fern has lately been found in Tasmania by Mr. Long, of the Museum staff. It is the smallest of our Filmy Ferns, and is doubtfully distinct from *Hymenophyllum tunbridgense*. Its rhizome is wiry and dry, and sustains few fan-like branches, green and delicate, each of about 1 cm. diameter. The noticeable feature as distinct from *H. tunbridgense* is that the spines on margins and sporangia are reduced to a minimum.

THE EXTINCT TASMANIAN EMU.

By

H. H. Scott,

Curator of Queen Victoria Museum, Launceston.

(Read 27th July, 1931.)

In a former communication to this Society, which was read on 8th October, 1923, dealing in part with the extinct King Island Emu, I gave, *inter alia*, some notes upon such Tasmanian Emu bones as had been to that date added to our Museum Collection.

Since then two other finds have reached us, and will now be passed in review.

THE SMITHTON FIND.

From an old contributor to our palæontological series of vertebrate remains—Mr. Tom Edwards—there came to us in October, 1924, a synsacrum, 1 femur, 1 tibio-tarsus, 2 tarso-metatarsi, and 1 cervical vertebra of a Tasmanian Emu recovered from Mowbray Swamp. These were all associated bones absolutely mature, using the word in its true osteological sense—as applicable only to bones whose external texture manifest the highest muscular development and the super-ossification incidental thereto. Everything considered, and having due reference to published notes, I consider this bird to have been a female.

THE FEMUR.

Greatest length	=	225 mm.
Proximal width	=	65 mm.
Distal width	=	68 mm.
Least girth of shaft	=	89 mm.

THE TIBIO-TARSUS.

Greatest length	=	422 mm.
Proximal width	=	88 mm.
Distal width	=	51 mm.
Girth in centre of shaft	=	72 mm.

THE TARSO-METATARSI.

RIGHT.

Length	=	349 mm.
Proximal width	=	55 mm.
Distal width	=	55 mm.
Girth in centre of shaft	=	73 mm.

LEFT.

Length	=	348 mm.
Proximal width	=	52 mm.
Distal width	=	54 mm.
Girth in centre of shaft	=	73 mm.

The details of right and left leg bones, thus given, serve the purpose of supplying data respecting bilateral asymmetry.

THE SYNSACRUM.

As far as my personal knowledge goes this is the only Tasmanian Emu's pelvis available for study, and it, unfortunately, is not perfect. Out of (*circa*) a 400 mm. length, only 270 mm. is represented in the specimen, its depth however—142 mm.—is a correct measurement. The iliac crest is intact for a length of 120 mm., and the proximal articulating centrum is still *in situ*. Distally—and therefore caudad—the mutilation is extensive. The acetabula and both ischiadic foramina are present, but both pubic and ischial processes are lost. A perfect pelvis, in direct comparison with one from an Australian Emu, would, I feel sure, reveal specific variation.

OSTEOLOGICAL NOTE.

The tarso-metatarsi of this Mowbray Swamp Emu are remarkable for the enormous development of the extensor digitalis grooves, which measured from the tibialis anticus tubercle run a distal course of 240 mm. before they subside upon the shaft. In width, the grooves are proximally 23 mm. wide—9 mm. in the centre—and 14 mm. distally. This ample space for muscular and tendonal lodgment speaks eloquently of the wonderful scratching and digging powers of the bird.

THE MOLE CREEK FIND.

From Mr. E. W. Clarke, of Mole Creek, we have received a tibio-tarsus of the Tasmanian Emu. This falls into line with our conceptions of the female bird. It is shorter, but mutilation in the item of post-mortem rubbing and grinding accounts for about 12 mm., the remainder coming within the range of individual variation.

TABLE OF SIZES.

Length (rubbed proximally) ..	=	400 mm.	(422 mm.).
Proximal width	=	83 mm.	(88 mm.).
Distal width	=	47 mm.	(51 mm.).
Girth in centre of the shaft ..	=	76 mm.	(72 mm.).

The figures given in brackets are the dimensions of the Mowbray Swamp bird, added for more direct comparison.

RECAPITULATIVE.

If the data collected from Mr. Ronald Gunn's specimen—as detailed by me—(*Pro. Roy. Soc. Tas.*, 1923, page 103) be regarded as having reference to the male bird, and the bones just passed in review these of females, then for the first time we have material for estimating the dimensional range incidental to the variation of sex in which the female was slightly smaller than the male bird.

ON THE OCCURRENCE IN TASMANIA OF *HYDROPHIS ORNATUS*, VARIETY *OCELLATUS*; WITH A NOTE ON *PELAMIS PLATURUS* (= *HYDRUS PLATURUS*)

By
E. O. G. Scott,
Assistant Curator, Queen Victoria Museum, Launceston.

(Read 27th July, 1931.)

I. *Hydrophis ornatus*, variety *ocellatus* Gray.

In 1927 a sea-snake was captured at Scamander by Mr. K. Gatenby and Mr. Ransom. The animal was subsequently presented to the Queen Victoria Museum, Launceston, by Mr. S. Tulloch Scott; and on making an examination of the specimen last year I came to the conclusion it was *Hydrophis ornatus*, variety *ocellatus* Gray. As the normal habitat of this species is the North Australian Coast (though an individual was caught in the Hawkesbury River, N.S.W., in 1925), the Scamander specimen was submitted to Mr. J. R. Kinghorn, C.M.Z.S., Zoologist, Australian Museum, Sydney, who kindly made an examination of it, and confirmed the determination. This adds a third species to the list of sea-snakes recorded from Tasmanian waters.

Dimensions: Total length, 1,310 mm.; tail, 150 mm.

Reference: Kinghorn, J. R.; "Snakes of Aus." (1929), p. 112.

II. *Pelamis platurus* (= *Hydrus platurus*).

The first specimen of *Pelamis platurus* (= *Hydrus platurus*) recorded from Tasmania was found at Scamander by Mr. J. Stanley Hodgson, and was made the subject of a paper to this Society by Mr. Clive E. Lord, Director, Tasmanian Museum, in 1919. The purpose of this note is to put on record the presence in the collection of the Queen Victoria Museum, Launceston, of a second specimen, captured at St. Helens by Mr. T. Haley (donated 10th February, 1921).

References: (1) (As *Hydrus platurus*), Boulenger, G. A.; Cat. Snakes, Brit. Mus. (1896), Vol. III., p. 267 (page-number misprinted in next reference as "26"); (2) (as *Hydrus platurus*), Lord, Clive E.; *Pap. and Proc. Roy. Soc. Tas.*, 1919, p. 22; (3) (as *Hydrus platurus*), Lord, Clive E., and Scott, H. H.; "Synopsis Vert. Anim. Tas." (1924), p. 109; (4) (as *Pelamis platurus*), Kinghorn, J. R.; "Snakes of Aus." (1929), p. 118.

PRELIMINARY NOTE ON THE SUPPOSED ABORIGINAL ROCK-CARVINGS AT MERSEY BLUFF, DEVONPORT.

By

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(Read 21st September, 1931.)

PART 1. INTRODUCTION.

The supposed Tasmanian Aboriginal Rock-Carvings at Mersey Bluff, Devonport, were brought under the notice of this Society by Mr. A. L. Meston, M.A., in a lecture delivered on 20th April, 1931. In conversation, Mr. H. Stuart Dove, F.Z.S., of Devonport, has informed me he has known of the existence of the markings for a number of years, his attention having first been called to them by Mr. Leek about 1914. Mr. Dove has also courteously supplied me with a copy of an article on the subject, illustrated by three figures, contributed by him to *The Australasian* of 15th September, 1923.

As, apart from the present series, no Tasmanian Aboriginal Rock-Carvings, of course, are known, considerable interest was naturally aroused by Mr. Meston's lecture. It was felt that the Queen Victoria Museum, Launceston, being the nearest scientific institution, should acquire, and have available for reference, some first-hand data concerning this important discovery, and I was instructed by the Museum Committee to visit the locality with this object. Accordingly, I spent the afternoon of 24th June, 1931, and the two days following at Devonport, and as a result of my investigation of the supposed carvings formed the opinion that these markings are very probably not of human, but of natural origin.

A paper, based on my Museum Report (which extends to about 100 pages, and includes over 100 figures), and incorporating certain additional data acquired on the occasion of several spare-time visits to Devonport, is in course of preparation and now nearing completion. In view, however, of the considerable length to which this proposed communication has already run, and of the difficulties surrounding the publication of this year's issue of the Society's *Papers and*

Proceedings, I have deemed it advisable—reluctant though I am to forego, in particular, the aid of figures—to submit, at the present juncture, merely a short preliminary note on the subject (to which, in preparation for publication, several items have been added).

It must be clearly understood that the present communication is to be regarded, not as a considered statement of the case for the natural origin of the Devonport rock-markings, but merely as a preliminary indication of the chief general lines along which that viewpoint is developed from a considerable body of evidence set forth in the detailed Paper it is proposed, should circumstances permit, to submit at a later date.

I wish to express my sincere thanks to Mr. A. L. Meston, M.A., and Mr. H. Stuart Dove, F.Z.S., both of Devonport, for much courteous assistance and information in connection with the markings; to Mr. D. Mahoney, D.Sc., Director of the National Museum, Melbourne, and Mr. A. S. Kenyon, M.I.E. Aus., for valuable notes on the character of rock-carvings found on the Mainland; to Mr. V. V. Hickman, B.A., B.Sc., for an estimation of the silica-content of the Devonport diabase; to Mr. V. Wellard, of the Mersey Marine Board, for the history of Quarries at Devonport; to Mr. R. Slater, of Kelso, whose hospitality made it possible for me to visit West Head; and to Mr. H. H. Scott, Curator of the Queen Victoria Museum, Launceston, for appreciated assistance in various ways. To the Chairman of the Museum Committee, His Worship the Mayor of Launceston, Alderman F. Boatwright, I am indebted for permission to incorporate in the present communication material from a Departmental Report.

PART 2. SUMMARY OF ARGUMENTS IN FAVOUR OF HUMAN ORIGIN.

The following summary records the principal considerations that have been, or may be, urged in favour of the human origin of the 75 rock-markings on Mersey Bluff regarded by Mr. Meston as being Aboriginal carvings:—

(1) General shape and character suggestive of human workmanship.

(2) Similar markings found outside Tasmania are of human origin.

(3) Specific imitation claimed for (or names, implying specific and deliberate imitation, bestowed upon) four markings:—(a) Fish; (b) Snake; (c) Haliotis Shell; (d) Bird's Head: to which add here, for convenience, (e) Concentric Circles.

(4) Carvings restricted to upper levels of Mersey Bluff headland. Mr. Meston has stated, "I have made a careful "search of every headland from Cape Grim to West Head, "hoping to find similar work of the aborigines, but have not "been successful in finding anything that appears like the "carvings at the Bluff; lines and deep markings I have found "in plenty, but carvings none."

(5) Carvings restricted to horizontal and subhorizontal rocks.

(6) Difficulty of conceiving any other adequate and available agency.

(7) Outlines never follow natural lines of weakness in the diabase.

(8) All in positions easily accessible to man.

(9) Carvings recognised as being such by observers familiar with Aboriginal rock-carvings in other countries.

(10) Aboriginal midden nearby, among sand-dunes of beach at Western base of the Bluff. On the strength of the supposed restriction of the carvings to the headland, and of the proximity of this midden, Mr. Meston has ventured to suggest that Mersey Bluff may possibly be of special ceremonial significance, in Walker's words, "a place of "assembly and consultation."

PART 3. SUMMARY OF ARGUMENTS IN FAVOUR OF NATURAL ORIGIN.

Though it involves a certain amount of duplication, I summarise separately below, first, the considerations that afford, to a greater or lesser extent, answers to the ten chief arguments in favour of the human theory; and, secondly, the additional independent considerations in favour of the suggestion of natural origin.

A. Answers to Arguments in Favour of Human Origin.

(1) *General Shape and Character suggestive of Human Workmanship.*

This, of course, is a principal point in debate. I can here only state that the supposed carvings (considered, for the moment, in complete dissociation from any other rock-

markings, either at Devonport, or elsewhere) seem to me to be more or less definitely unsuggestive of Aboriginal workmanship in the following ways:—

(a) *General Shape* (cases of specific imitation are discussed later). Ovate, pyriform, reniform, and other simple curvilinear outlines are certainly superficially suggestive of human endeavour, but, on the other hand, these outlines are common ones in Nature—persistent annular lichen-transfers, for instance, affording very closely comparable figures, not only as regards general shape and general size, but also as regards details of form (e.g., width of band, spurs, abrupt cessation of outline, secondary loops, etc.), and details of proportion (e.g., ratio of length to maximum breadth; in pyriform examples, relative position of point of maximum width; etc.).

(b) *Depth of Groove.* This reaches a maximum of 54 mm. On the other hand, several of carvings have a maximum depth of less than 5 mm.

(c) *Variation in Depth of Groove in Individual Examples.* Maximum depth of 12 carvings = 10, 3, 3.5, 3, 7, 14, 9.5, 18, 26, 19, 54, 15.75 mm. Minimum depth of same examples = virtually zero, zero, virtually zero, 1, 2.25, 5.5, virtually zero, 1, 3, 2, 5, virtually zero, respectively. In individual examples, the depth changes from 18 to 6.75 mm. in the course of about 25 mm.; from 8 to 1.5 mm. in 5 mm.; from 16 to 4.5 mm. in about 20 mm.; from 22 to 10 mm. in about 4 mm.; from 54 to 25 mm. in about 50 mm.; etc.

(d) *Width of Groove.* The groove varies in width from 2 mm. to 45 mm., or more.

(e) *Variation of Width of Groove in Individual Examples.* Selected instances include:—from 11 to 2; from 13 to 3; from 27 to 6; from 45 to 8; from 20 to 8 mm.

(g) *Cross-section.* Various examples give the following associated measurements of depth and width of groove:—18 mm. (depth) and 8 mm. (width); 16.5 and 6 mm.; 26 and 6 mm. (here, an ordinary lead-pencil, about 7.5 mm. in diameter, even when sharpened to a cone 14 mm. high, cannot be made to reach the bottom of the groove, which is, as noted, just over an inch deep); 18 and 7.5 mm.; 16.5 and 7 mm.; 19 and 8 mm.; 11.25 and 6.5 mm.

The wall of the groove is not infrequently sheer, and occasionally overhanging; and at the same point one wall

may be virtually vertical while the other wall presents a very gradual slope.

At one point in the Snake, the groove is somewhat flask-shaped in vertical cross-section, with a constricted neck following on a mouth 7 mm. across: the groove here is 16.5 mm. deep.

(h) *Small Radii of Curvature of Arcs of Deep Grooves.* In one case, in a groove 16-19 mm. deep, and 6-8 mm. wide, the rate of curvature is too rapid for a thin steel blade, 9.75 mm. across, at once to follow the outline and keep evenly in contact with the bottom of the groove.

(i) Groove not infrequently undercut at, or near, bottom.

(j) Frequent sudden complete hiatus in outline. Partial interruptions, involving a marked abrupt change in depth and width of groove, also occur.

(k) Common association of cessation of groove, either as hiatus in outline or as free extremity of linear appendage, with a pronounced distal fanning-out.

(2) *Similar Markings Found Outside Tasmania are of Human Origin.*

(a) The markings at Devonport certainly present considerable general resemblance in shape to other rock-markings definitely known to be of Aboriginal origin. They exhibit, however, several characteristic features of outline that are probably, as far as I can ascertain, not duplicated in carvings of, at any rate, Australian workmanship. Unfortunately, I have no first-hand knowledge of the well-known mainland series. Mr. A. S. Kenyon, M.I.E. Aus., however, has very kindly supplied me with much detailed information in answer to a lengthy questionnaire. From this I select the following items that serve to illustrate the marked differences between the Australian Aboriginal carvings and the rock-markings at Mersey Buff:—

(b) Question. (1) Any recorded examples in diabase? (2) In basalt? (3) If "no" to either or both above, any reason, apart from hardness—e.g., lack of rocks?

Answer. "(1) None. (2) None—if [in both cases] "the query be confined to incised lines: but "scratched designs have been found on diorite, "S. Aus., and scratched lines on cylindro-conical

"stones of hard sandstone in a single case. The "case of these cylindro-conical stones is typical: "all those of soft stone, sandstone, limestone, "or slate are incised, those of hard sandstone, "etc., are without incisions save the instance "above. Stone churingas are all of soft slates."

It may be noted that in a Paper, "Aboriginal Rock-Carv- "ings in South Australia," read before the Australasian Association for the Advancement of Science, at the 1928 Session, Mr. C. P. Mountford records a group of circles and "cup- "and-ring" carvings, found on the bank of the Rocky River, about 4 miles south-west from Huddlestone, on a boulder described as being of quartzite. Concerning this boulder, Mr. Mountford says, "It is very likely that a stone of this descrip- "tion would have special ceremonial value." More than 200 carvings, from 14 localities, are described in this Paper, all of them, with the single exception noted, being executed in slate or in "soft Miocene limestone."

(c) Question. Average depth of outlining groove?

Answer. "One centimetre. I have never measured "them accurately. Very often with weathering "or wearing they are very shallow—2 or 3 mm. "or less."

(d) Question. Maximum depth of groove?

Answer. "I do not recollect any two centimetres "deep."

(e) Question. Usual form of ogroove in vertical section?

Answer. "The groove may be roughly described as "an equilateral triangle in section with a some- "what rounded apex." (Sketch attached.)

(f) Question. Anything like this met with—a groove 26 mm. deep and 6 mm. wide?

Answer. "Not to my knowledge. I have seen many "around Port Jackson, the Hawkesbury, in "North-West N.S.W., S.W. Queensland, and "Northern South Australia."

(g) Question. Ever undercut?

Answer. "No. Decidedly not."

(h) Question. Ever anything like this (sketch of flask-shaped groove-section attached) in vertical section?

Answer. "No."

The marked differences in the character of the groove in the Australian rock-carvings and the markings at Devonport—an aspect I conceive to be of primary importance—will be realised on comparing the notes above with the data recorded in the preceding section.

(3) *Examples of Supposed Specific Imitation.*

In so far as they can readily be summarised, the chief points of criticism of the examples of supposed specific imitation are as follows:—

A. *Fish.*

(a) Unconvincing outline—called by other observers "Leaf" and "Owl."

(b) No fins.

(c) Two large irregular series of pits (max. d = 16 mm.) in head region apparently not representatively significant.

(d) Inwardly projecting spur (l = 72 mm.) in head region apparently not representatively significant.

(e) "Tail," unlike rest of body, not outlined by a groove, but is itself a single depression.

(f) Variation in depth of groove. Depth at 37 points (successive, but not equidistant) = 18, 6.75, 8, 1, 6, 5, 7, 1, 5, 5, 0.5, 0, 3, 1, 2, 3, 1, 2.5, 3.5, 1, 9, 5, 8.25, 5, 9, 8, 5, 13.5, 18, 10, 11, 6, 8, 2, 3.5, 1.5, 8 mm. The depth changes from 18 to 6.75 mm. in about 25 mm., and from 8 to 1.5 mm. in 5 mm.

(g) Variation in width of groove. Width at the 37 points whose depth-measurements are noted above = 21, 16, 24, 20, 20, 18, 24, 14, 22, 17, 10, 0, 18, 7, 10, 16, 6, 18, 15, 13, 26, 24, 25, 27, 25, 22, 21, 23, 23, 24, 23, 19, 16, 10, 15, 8, 17 mm. The width changes from 18 to 7 mm. in about 20 mm., and from 17 to 8 mm. in 5 mm.

(h) In deeper head-region, outer wall of groove comparatively sheer, inner wall very gradually sloping.

(i) Anteriorly, outer wall slightly undercut.

(j) Outline barely traceable for a stretch of about 43 mm.

(k) Outline duplicated by crustaceous lichens.

(l) Fish-like intaglio (l = 162; b = 38; max. d = 12 mm.) in recently worked diabase quarry at West Devonport.

(m) Fish-like intaglio (l = 170; b = 70; max. d = 16.5 mm.) in diabase on right bank of Mersey, some 2 or 3 miles from Bluff.

(n) Fish-like outline (l= 232; b = 112; max. d = 8.5 mm.) in diabase near West Tamar Road, Launceston.

(o) Small size of carving (l, between parallels = 328; w = 160 mm.); outlined representations of fish in Australian Aboriginal carvings usually being very large (up to 30 feet long).

(p) Ratio of length to breadth in carving is 328 to 160 mm. (i.e., 2.05), and in example mentioned in note (n) is 232 to 112 mm. (i.e., 2.07).

B. *Snake.*

(a) Unconvincing outline (head outlined by groove; tail itself a groove; one large and three small internal independent elements).

(b) Numerous scattered shallow depressions to immediate left of carving, and two isolated shallow arcs, one outside upper right, other outside and subparallel with lower right, corner.

(c) Variation in depth of groove. Thirteen measurements of depth (at non-equidistant intervals) = 3, 2, 10, 18, 18.5, 19, 16.5, 11.25, 4.5, 9, 14.5, 9.5, 7 mm.

(d) Variation in width of groove. Width at the 13 points whose depth-measurements are noted above = 6, 5, 6, 7.5, 11, 8, 7, 6.5, 7, 8, 11, 7, 15 mm.

(f) A depth of 16.5 mm. associated with a width of only 7 mm., and a depth of 18 mm. associated with a width of only 7.5 mm.

(g) Groove undercut in 5 separate regions, one of which is 35 mm. long.

(h) Walls of groove often comparatively sheer.

(i) Vertical cross-section of groove, at lower left corner, flask-shaped (7 mm. wide at "mouth"; 16.5 mm. high).

(j) Groove in diabase at Cataract Hill, Launceston, forming only 3 sides of a rectangle, is 92 mm. long (in carving, l = 112 mm.); has completely formed "head," 25 mm. wide (width of "head" in carving = 26 mm.); width of groove varies from 7.5 to about 16 mm.; depth varies from 4 to 16.5 mm.

(k) Groove below hightide-line at Mersey Bluff presents an outline of same generic character as Snake. Depth at 6 points = 8, 15, 19, 10, 5.5, 3.5 mm. Width of groove at 4 points = 5, 18, 15, 7.5 mm.

(l) Ratio of length to breadth in carving is 112 to 90 mm. (i.e., 1.24), in example mentioned in note (k) is 95.5 to 70 mm. (i.e., 1.36).

C. *Haliotis Shell.*

(a) Name applied to one portion only of large, otherwise innominate marking.

(b) Resemblance is remote (general outline unsatisfactory; presence of spur; etc.).

(c) From middle of floor of groove, here 40 mm. wide and 35 mm. deep, a large boss rises to a height of 23 mm.

(d) May possibly be connected with spiral growth-lines in lichens.

(e) Remainder of carving presents a number of features difficult to reconcile with human theory, e.g., max. d. of groove = 54 mm.; d. of groove changes, in course of about two inches, from 25 to 54 mm.; large basal loops; interruption of outline; large and small independent external elements; large internal spur with distal expansion; three large independent internal elements; etc.

(f) On same rock are "non-carvings," including a rounded marking, with scalloped outline (l = 220; b = 200; max. d. = 14.5 mm.); an intaglio (l = 121; b = 120; max. d. = 27 mm.); an irregular groove (l = 730; max. d = 30 mm.); an intaglio (l = 310; b = 56; max. d. = 33 mm.); a groove (l = about 900 mm.; b = about 51 mm.; this groove, observed on a wet day, contained water to a depth of 97 mm.); etc.

D. *Bird's Head.*

(a) Resemblance very remote.

(b) "Eye" apparently a naturally weathered depression, with part of periphery raised as a rim.

(c) No "eye" in other carvings of generically similar outline.

(d) Rock-surface flaked away for some distance round anterior portion to a depth comparable with that of the groove.

(e) Outline closely repeated by lines of pneumatological differentiation and weakness in diabase.

E. *Concentric Circles.*

(a) Not concentric circles. Consists of the following elements:—(1) a very nearly circular element, interrupted (grooves expanding distally) near "three o'clock," and giving rise to (2) a pointed, outwardly projecting spur near "twelve o'clock"; (3) a less accurately circular element, taking its origin as a pointed groove practically in contact with the end of the spur arising from the inner element, and, apart from a semi-interruption towards "four o'clock," following a course for some distance approximately concentric with that of the inner element, but swinging out noticeably from it towards "ten o'clock," and terminating in a free extremity just before "twelve o'clock"; (4) an inwardly projecting spur arising from the inner element near "eight "o'clock"; (5) an outwardly projecting spur arising from the inner element near "ten "o'clock"; and (6) a short detached external element at "three o'clock."

(b) Remarkable combination of skill and inexpertness.

(c) Near "two o'clock," where outer groove is 8.5 and inner groove is 9.5 mm. below general rock-surface, the narrow region between them is 7.5 mm. below general rock-surface.

(d) On same rock with this carving, 78 mm. from it, occurs a rectangular marking with secondary rectangular appendage. This marking, which is, so far as I am aware, not regarded as a carving,

is slightly greater in area than the concentric circles, and has a max. d. of 16.5 mm. (max. d. of circles = 15.75 mm.).

(e) Below high tide line at Bluff occur concentric ovate grooves—outer groove, l = 62, b = 45, w = 2-3, d = 1 mm.; inner groove, l = 40, b = 25, w = 2-3, d = 2.5 mm.

(f) On headland occur among the "non-carvings" two concentric arcs forming about 1-3 of a broad ellipse; width of groove = 4-5 mm.; d = 5 mm.; chord of inner arc = 85 mm.

(g) Lichens at Cataract Hill, Launceston, observed forming conspicuous but very shallow concentric circles of erosion. Spurs, projecting inward and outward, present as in carving. Difference between maximum and minimum diameters of carving = 7.2 %; ditto, in the case of 8 lichens (on neighbouring rocks, Cataract Hill) = 3.8, 0.9, 4.1, 6.8, 4.5, 4.1, 10.3, 3.1 %; av. = 4.7 %.

4. *Supposed Restriction to Upper Levels of Bluff.*

(a) A carving (l = 265; b = 195; max. d. = 49 mm.), more striking than 90 % of those at the Bluff, occurs on a rock (below high tide-line) about 11 yards southward from the retaining wall at the Western end of Devonport Bridge, some 2 miles from the Bluff.

(b) Other examples (up to 30 mm. deep) occur on both banks of the Mersey above the Bridge.

(c) At, and below, high tide-line at Mersey Bluff (particularly on N.W. aspect) are numerous grooves of ovate, pyriform, reniform, and other outlines. Dimensions of 6 examples (l and b = external length and breadth; w = average width of groove; d = maximum depth):—(1) ovate, with curved terminal appendage, l (with appendage) = 115, b = 54, w = 6, d = 25 mm.; (2) ovate, with transverse internal groove, 5.5 mm. deep, l = 50, b = 43, w = 9, d = 5.5 mm.; (3) pyriform, l = 60, b = 35, w = 6, d = 24 mm.; (4) reniform, l = 95, b = 59, w = 5, d = 24 mm.; (5) rectangular, l = 196, b = 196, w = 40, d = 56 mm. (or more); (6) pyriform, with subsidiary internal loop, l = 92.5, b = 68, w = 2, d = 4 mm.

These markings are closely comparable in size and general shape with corresponding members of the carving-series, and exhibit similar characteristic curved appendages,

transverse internal grooves, internal subsidiary loops, detached elements, bosses rising from floor of groove, interrupted sections, and so on.

In some cases the groove, particularly apically in ovate examples, has formed (up to a depth of 22 mm.) immediately beneath an overhanging hood-like lamina of diabase, which, on being removed (readily enough) by the fingers, exposes the groove.

(d) On vertical faces of diabase-quarries (6-15 feet above general ground level) at East and West Devonport, worked recently, certainly within the last 20 years, occur, among others, the following well-marked grooves:—(1) ovate, l = 60, b = 49, w = 10, d = 4 mm.; (2) pyriform, l = 190, b = 89, w at 5 points = 14, 27, 11, 18, 30 mm.; d at same points = 3.25, 7.5, 5.25, 3.5, 7.75 mm.; (3) ovate, l = 88, b = 75, w = 10-20, d = 8 mm.; (4) reniform, l = 105, b = 53, w = about 8, d = 6 mm.; (5) fish-like intaglio, l = 162, b = 38, d = 12 mm.; (6) ovate, l = 40, b = 30, d = 6 mm. Examples (2), (5), and (6) occur in much-weathered diabase in the Mersey Marine Board's Quarry, first worked, Mr. V. Wellard informs me, in 1912. Examples (1), (3), and (4) are from Mr. Coulter's Quarry at East Devonport, and occur on a face almost certainly opened up during the present century.

(e) Wherever I have been able to examine diabase formations, I have found grooves in the shape of closed curves. These are at once much rarer, and, on the average, much shallower than the Devonport examples. It is, I think, a matter of considerable importance to observe that the unclosed curves, or "non-carvings" are correspondingly rarer and correspondingly shallower than the non-carvings on the Bluff (see section (6)). Notes on 6 selected examples:—(1) Cataract Gorge; ovate with terminal appendage; l = 88, b = 70, w = 9-15, d = 8 mm.; (2) Cataract Gorge; pyriform; l = 115, b = 72, w = 11-14, d = 4 mm.; (3) Ravenswood; pyriform with rectangular appendage; l = about 145, b = 74, w = 4-11, d = 6.5 mm.; (4) West Head; pyriform; l = 136, b = 64.5, w = 5-9, d = 2 mm.; (5) West Head; pyriform; l = 48, b = 24.5, w = 5.5-10, d = 5 mm.; (6) Waverley, Launceston; ovate with interrupted outline; l = 60, b = 43, w = 4.5-12, d = 5.5 mm. (This last example is more clearly and boldly cut, and decidedly more striking than several of the poorer, small supposed carvings of similar character.)

(5) *Supposed Restriction to Horizontal and Subhorizontal Surfaces.*

(a) Area on headland of Mersey Bluff on which the carving-series occurs consists chiefly of horizontal and subhorizontal rocks.

(b) Both carvings and non-carvings are in general restricted to these.

(c) At least one carving does occur partly on a sloping and partly on a subvertical face. Further investigation is needed.

(d) The place of both the carvings and non-carvings at Devonport is apparently taken on vertical rock-faces by pronounced exfoliations of comparable size and shape.

(e) In localities other than Devonport the grooves in the diabase are usually, but not exclusively, on the horizontal, and the exfoliations chiefly on the vertical faces.

(6) *Difficulty of Conceiving any other Adequate and Available Agency.*

(a) *As regards shape.* The characteristic shapes of the supposed carvings are duplicated in whole or in part by numerous small outlines scratched on the rock-surface at Devonport and elsewhere as finely as if incised by a needle; by the grooves found below the tide-line at Devonport (section 4 (c)); by grooves in recently worked quarry-faces at Devonport (section 4 (d)); by grooves in diabase in localities other than Devonport (section 4 (e)); by extensive exfoliations on vertical diabase-faces at Devonport and elsewhere; and in many cases with great fidelity by rock-lichens.

(b) *As regards depth and character of the groove.* Scattered about the area on the Bluff headland in which the carvings occur, and often on the same rocks with them, are numerous other well-defined grooves, usually with unclosed outlines, and intaglios. As Mr. Meston's restriction of his list of carvings to 75 examples indicates, these markings are not regarded by him as being of Aboriginal origin. For convenience, I designate them non-carvings. Some measurements of non-carvings appear below.

(c) *Length.* From a few mm. to, e.g., about 900, 950, 730, 430, 240, 310 mm.

(d) *Depth of groove.* Measurements of maximum depth include:—33, about 100, 38, 27, 40, 33, 24.5, 31.5 mm.

(e) *Variation of Depth of Groove in Individual Examples*:—(1) from 4.5 to 1 mm.; (2) from 21 to 6 mm.; (3) from 11 to 3.5 mm.; (4) from 20 to 5.5 mm.; (5) from 18.75 to 2 mm.; (6) from 14.5 to 0 mm.; etc. Often abrupt changes in depth, e.g., from 10 to 0 mm., from 13.75 to 3.5 mm., from 5.5 to 3 mm., from 31.5 to 6 mm., in the course of a few mm.

(f) *Width of Groove.* Varies from 1 or 2 mm. to 82 mm. or more.

(g) *Variation of Width of Groove in Individual Examples*:—(1) from 18 to 8 mm.; (2) from 26 to 11 mm.; (3) from 35, or more, to 6 mm.; (4) from 51 to about 8 mm.; (5) from 82 to 35 mm.; (6) from 56 to 40 mm.

(h) *Cross-Section.* Various examples give the following associated measurements of depth and width of groove:—(1) 14.5 (depth) and 10 mm. (width); (2) 31.5 and 11 mm.; (3) 22 and 13 mm.; (4) 40 and 17 mm.; (5) 19 and 8 mm.; (6) 19.5 and 5 mm. Wall may be sheer, overhanging, or gradually sloping. One example, 31.5 mm. deep, 11 mm. wide, is somewhat flask-shaped in vertical cross-section.

(i) Some deep grooves have a comparatively small radius of curvature.

(j) Undercut in a number of cases.

(k) Complete and partial interruptions in outline occur.

(l) Common association of cessation of groove, either as hiatus in outline or as free extremity, with a pronounced distal fanning-out.

(m) These grooves are not, nor, I think, plausibly can be, claimed as being of Aboriginal origin. The agency responsible for their incision would be capable, in so far as depth and general character of the groove are concerned, of incising the grooves of the supposed carvings.

(n) Lichens, which are sometimes very long-lived, have been known to eat into rock to a depth of 30 mm. Lichens have been known to eat into glass, and a determination kindly made for me by Mr. V. V. Hickman, B.A., B.Sc., shows that the Devonport diabase has a silica-content of 46 %. On the other hand, it is to be noted that a much higher percentage of silica occurs in other of our igneous rocks.

(7) *Outlines Never Follow Natural Lines of Weakness in the Diabase.*

(a) It would be somewhat remarkable, from the viewpoint of human theory, if this were so. I have notes and

sketches of lines of weakness forming portions of, and extensions of, the main outline.

(b) In some cases cracks or furrows run on to, or right across, the carving, maintaining their own integrity while traversing the groove. If the supposed carvings are of human origin, these cracks must be of subsequent formation. It is of interest to observe that similar furrows maintain their integrity in depressions and grooves formed by crustaceous lichens.

(8) *All in Positions Easily Accessible to Man.*

(a) All the markings recognised as carvings are accessible to man. (Further investigation on this point is desirable.)

(b) Some examples are in decidedly awkward situations.

(c) Of the markings here noted from below the tide-line at Mersey Bluff, some (e.g., those with large lamellar hoods overhanging the groove) are not accessible by Aboriginal implements.

(d) Grooves here noted from quarry-faces at Devonport, opened up within the last 20 years or so, are not accessible to Tasmanian Aboriginals.

(9) *Carvings Recognised as Being Such by Observers Familiar with Aboriginal Rock-Carvings in Other Countries.*

In a summary such as the present, it can merely be said that other observers, similarly qualified, hold an opposite opinion.

(10) *Aboriginal Midden nearby, among Sand-dunes of Beach at Western Base of Bluff.*

(a) Aboriginal middens found at frequent intervals along practically the whole Northern Coast of the Island.

(b) Carvings not restricted to Mersey Bluff.

B. Additional Arguments in Favour of Natural Origin.

In the preceding sections (Part 3; A; Nos. 1-10) a general answer to the chief arguments in favour of the human theory has been outlined. The formulation of this reply has naturally involved the general statement of a large part of the case for the natural origin of the markings; and the opportunity has been taken to draw attention to several points (e.g., occurrence of deep curvilinear grooves in diabase below the tide-line and in quarries) that may perhaps best be regarded not merely as answers to arguments for the Aboriginal theory, but as independent considerations in favour of the suggestion of natural origin.

Additional independent considerations — of varying evidential weight—in favour of the theory of natural origin include the following:—

(11) In many of the ovate examples below the tide-line at Mersey Bluff the whole area enclosed by the groove is elevated into a knob (a structure, I presume, probably allied to that of orbicular Websterite), usually rising a few mm., but at times as much as 800 mm., above the general surrounding surface. On re-examining the ovate carvings on the headland, I found that in a number of instances a ruler balanced on the central portion of the area enclosed by the groove rode quite clear of (in marking on same rock with snake 3-4 mm. above) the general surrounding surface.

(12) Absence from the known range of Tasmanian Aboriginal implements of a tool capable of incising grooves of such character. (See details of depth, width, and cross-section of groove in section (1).) It may be observed that a neatly scratched modern design at the Bluff (comprising an approximately equilateral triangle, two initials, and the figures 66), in which the tool-marks are visible, has a maximum depth of 1.75 mm., and an average depth of 1 mm. or less.

(13) Though there is no constant ratio between size of outline and depth of groove, the deeper grooves occur in general in the larger markings. The largest marking of the series is notably the deepest.

(14) The deeper grooves, among both the carvings and the non-carvings on the headland, are found on the Northern and North-Western (i.e., the most exposed) aspects of the Bluff.

(15) Though personally I attach little weight, from an evidential point of view, to such a negative consideration, it appears, on the face of it, surprising that the refractory igneous diabase should be selected for the incision of carvings to the complete neglect, as far as is known, of the readily accessible softer sedimentary rocks (e.g., slates, and the Midland sandstones).

(16) Some evidence is available of the formation of fairly pronounced curvilinear grooves in concrete, cement, and dressed freestone. Further investigation is needed.

(17) The Tasmanian diabase exhibits in great number curves of pneumatological differentiation closely comparable in area and outline with the typical carvings, the resemblance extending even to the minor features of proportion and form.

These areas of differentiation may manifest themselves as (a) mere superficial outlines of segregation, or, after being acted upon by weathering agencies, as (b) grooves, (c) exfoliations and intaglios, (d) lines or curves in relief.

(a) Example. Dimensions of regular pyriform carving, with corresponding dimensions of regular pyriform superficial segregation—outline (Cataract Hill, Launceston) in brackets for comparison (all measurements internal):—l = 140 mm. (196 mm.); b = 75 mm. (114 mm.); max. breadth expressed as a percentage of length = 54 % (58 %); vertical distance of max. breadth from top (i.e., broader end) expressed as a percentage of length = 25 % (26 %).

(b) Grooves. See Part 3; section 6.

(c) Exfoliations. I possess specimens from Devonport and elsewhere, all detached by the finger-tip. Dimensions of an ovate example (Trevallyn, Launceston):—l = 189 mm.; b = 117 mm.; max. d. = 33mm.; wt = 2 lbs. 2¼ oz.: larger specimens are obtainable.

These exfoliation-flakes *in situ* and the intaglios formed by their weathering-out are exceedingly common, particularly on vertical and subvertical faces. It may be of interest to mention here that while on a visit to West Head, M. Landgraff, Mr. T. Slater, and myself discovered in the Cambrian or Pre-Cambrian schists, between Kelso and West Head, an extraordinary series of deep and very clearly defined water-worn intaglios, the smaller and more numerous members of which exhibit a striking resemblance to a human footprint.

(d) At, and below, the hightide-line on the N.W. of Mersey Bluff, outlines comparable in shape and size with those of the common carvings are raised in appreciable, sometimes in high, relief. Occasional curves in relief occur also on the headland itself.

(18) Complete absence at Devonport, so far as I am aware, of the track-marks that form such an important element in the great majority of extensive series of Australian Aboriginal rock-carvings.

(19) In conversation, Mr. Meston has informed me that in the period of less than three years during which he has observed the markings five examples of his original list of eighty have weathered out. Mr. Dove tells me also that of the three examples figured by him in *The Australasian* in 1923 one is now nearly indecipherable.

PART 4. CONCLUSION.

As a personal opinion, based on the evidence available, I have very little doubt indeed that the 75 rock-markings at Mersey Bluff claimed by Mr. Meston to be carvings are not of Aboriginal origin. I regard them as being striking, but somewhat arbitrarily selected, items in an extensive series of natural erosions.

As regards the mode of formation, the data collected would seem to show that the erosion has in general occurred along lines of inherent pneumatological weakness in the Mesozoic diabase. There is some reason to believe that, in addition to inorganic weathering-agencies, rock-lichens have played a not unimportant part in the process of erosion of the grooves, and in some cases it is possible they have initiated the groove.

It has already been observed that the present communication does no more than form an outline of the general trend and scope of the chief objections to the theory that these rock-markings are of Aboriginal workmanship. It is proposed, should it prove expedient, to make a detailed examination of the problem the subject of a later paper. In the meantime, the case for the natural origin of the supposed carvings merits, I think, serious consideration.

THE ROYAL SOCIETY OF TASMANIA

1931

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HIS MAJESTY THE KING.

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HIS EXCELLENCY SIR HERBERT NICHOLLS, K.C.M.G.

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THE ROYAL SOCIETY OF TASMANIA MEDAL.

List of Awards:

1927 L. Rodway, C.M.G.

1930 Clive Lord, C.M.Z.S., F.L.S., F.R.A.I.A.

Note.—The Royal Society of Tasmania Medal was established in 1927. It is awarded for eminence in research and for work of outstanding merit on behalf of the Society and the State (*vide* Abstract of Proceedings, P. & P. 1927, pp. 212-214).

IAL MUSEU
VICTORIA

R. M. JOHNSTON MEMORIAL.

THE R. M. JOHNSTON MEMORIAL MEDAL.

List of Awards:

1923 Sir T. Edgeworth David, K.B.E., C.M.G., B.A., F.R.S., F.G.S.

1925 Professor F. Wood-Jones, M.B., B.S., M.R.C.S., L.R.C.P., D.Sc.

1929 R. J. Tillyard, M.A., Sc.D. (Cantab.), D.Sc., F.R.S., F.N.Z. Inst., F.L.S., &c.

IAL MUSEU
VICTORIA.

ABSTRACT OF PROCEEDINGS, LIST OF MEMBERS, &c.

On account of the elimination of the Government Grant-in-aid of Printing, and the general economic depression, the Abstract of Proceedings and List of Members are omitted, and the Report printed in abstract only.

The Council regrets that present circumstances render it necessary to reduce the annual volume, but the present financial position is a matter of grave concern to the Council.

THE ROYAL SOCIETY OF TASMANIA

ANNUAL REPORT, 1931

(ABSTRACT.)

The Annual Meeting was held on the 16th March, 1931. The following were elected as Members of the Council for 1931:—Dr. A. H. Clarke, Mr. W. H. Clemes, Dr. W. E. L. Crowther, Mr. E. T. Emmett, Dr. A. N. Lewis, Mr. L. Rodway, Mr. J. Reynolds, Mr. E. E. Unwin, Mr. F. E. Ward, and Mr. C. Lord (*ex officio*).

Mr. W. E. Taylor was elected Honorary Auditor.

The Council at its first meeting made the following appointments:—

Chairman—Mr. W. H. Clemes, B.A., B.Sc.

Secretary—Mr. Clive Lord.

Standing Committee—Messrs. Clemes, Lord, and Dr. Lewis.

Trustees of the Tasmanian Museum and Botanical Gardens—Drs. Clarke, Crowther, Lewis, Messrs. Clemes, Emmett, and Unwin.

Meetings.

Ten meetings were held, at which a number of valuable papers were read and lectures given.

Finance.

The total withdrawal of the Government grant has thrown the Society entirely on its own resources, with the result that the maintenance of the Library and the printing of the proceedings of the Society has entailed a heavy tax on the Society's resources.

Papers and Proceedings.

The printing of the Papers and Proceedings for the year 1931 has been delayed owing to financial considerations, but it is hoped to publish the volume in the near future.

Natural Sciences.

The Council of the Society, being of the opinion that it is urgently necessary for the well-being of the State of Tasmania that greater facilities be afforded for the study of and education in the natural sciences, took steps to bring the matter under the notice of the Government, with the result that the Honourable Minister for Education arranged a conference, and a Committee has been appointed to bring up a report.

Rodway Herbarium.

The Society interested itself in assisting the Trustees of the Tasmanian Museum to purchase the Rodway Herbarium, and the splendid response made by Members of the Society and others enabled this most valuable collection to be retained in the State.

Branches and Sections.

The Northern Branch and the several sections of the Society continued their activities in a satisfactory manner.

General.

Owing to the Secretary (Mr. Lord) visiting England as one of the Australasian Delegates to the Centenary Meeting of the British Association, Mr. E. T. Emmett acted as Honorary Secretary for six months, and it is desired to place on record the Society's appreciation of his services.

Obituary.

It is with regret that the Society has to record the death of the following Members:—

Professor Alexander McAulay.

Mr. A. W. Courtney Pratt.

Mr. Alan C. Walker.

BRANCH REPORTS

NORTHERN BRANCH.

ABSTRACT REPORT.

The following were elected as Members of the Council of the Northern Branch for 1931:—Hon. T. Shields, M.L.C. (Chairman), Messrs. F. Heyward, F.R.V.I.A., W. R. Rolph, R. S. Padman, D. V. Allen, B.Sc., F. Smithies, J. R. Forward, R. A. Scott, and E. O. G. Scott (Hon. Secretary).

Five meetings were held during the year, and several interesting and instructive lectures were given. In addition, certain papers were read and discussions held. Generally, the Branch has had a successful year.

SECTION REPORTS

The only section in active operation was the Educational Section. Neither the Historical nor the Botanical Section held meetings.

THE ROYAL SOCIETY OF TASMANIA.

STATEMENT OF ACCOUNTS FOR THE YEAR ENDED 31/12/31.

GENERAL FUND.

RECEIPTS.

	£	s.	d.
Balance Brought Forward	11	6	7
Subscriptions	217	7	0
Receipts, Special Meetings	29	5	11
Rent of Room	26	3	0
Miscellaneous	6	14	4
	£290	16	10

EXPENDITURE.

	£	s.	d.
Salaries	39	0	0
Papers and Proceedings, 1930 (Part)	110	0	0
Cost of Meetings, Notices, Advertising, and General Printing	84	9	5
Library	14	4	1
Insurance	5	18	9
Light and Fuel	4	0	10
Miscellaneous	5	9	5
Postages and Petty Cash	13	0	0
	£276	2	6
Credit Balance Carried Forward	14	14	4
	£290	16	10

Examined and certified to be correct,

WALTER E. TAYLOR,
Hon. Auditor.

19/2/32.

JOHN REYNOLDS, Hon. Treasurer.
CLIVE E. LORD, Secretary.

14/1/32.

THE ROYAL SOCIETY OF TASMANIA.

R. M. JOHNSTON FUND.

RECEIPTS.	£	s.	d.	PAYMENTS.	£	s.	d.
Interest (Perpetual Trustee Co.)	14	12	0	Dr. Balance Brought Forward	13	13	6
				Cr. Balance Carried Forward	0	18	6
	£14	12	0		£14	12	0

Examined and certified to be correct,

WALTER E. TAYLOR,
Hon. Auditor.

19/2/1932.

JOHN REYNOLDS, Hon. Treasurer.
CLIVE E. LORD, Secretary.

14/1/32.

MORTON ALLPORT MEMORIAL FUND.

RECEIPTS.	£	s.	d.	PAYMENTS.	£	s.	d.
Balance Brought Forward	1	1	1	Books for Library	5	0	0
Interest (Perpetual Trustee Co.)	8	18	8	Balance Carried Forward	4	19	9
	£9	19	9		£9	19	9

Examined and certified to be correct,

WALTER E. TAYLOR,
Hon. Auditor.

19/2/1932.

JOHN REYNOLDS, Hon. Treasurer.
CLIVE E. LORD, Secretary.

14/1/32.

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The Royal Society of Tasmania

PAPERS & PROCEEDINGS

OF

THE ROYAL SOCIETY OF TASMANIA

FOR THE YEAR

1932

NATIONAL MUSEUM
VICTORIA.

(With 23 Plates and 1 Text Figure)

ISSUED 10TH MAY, 1933

PUBLISHED BY THE SOCIETY

The Tasmanian Museum, Argyle Street, Hobart

1933

Price: Five Shillings

The responsibility for the statements and opinions in the following papers and discussions rests with the individual authors and speakers; the Society merely places them on record.

The Royal Society of Tasmania

The Royal Society of Tasmania was founded on the 14th October, 1843, by His Excellency Sir John Eardley Eardley-Wilmot, Lieutenant-Governor of Van Diemen's Land, as "The Botanical and Horticultural Society of Van Diemen's Land." The Botanical Gardens in the Queen's Domain, near Hobart, were shortly afterwards placed under its management, and a grant of £400 a year towards their maintenance was made by the Government. In 1844 His Excellency announced to the Society that Her Majesty the Queen had signified her consent to become its patron; and that its designation should thenceforward be "The Royal Society of Van Diemen's Land for Horticulture, Botany, and the Advancement of Science."

In 1848 the Society established the Tasmanian Museum; and in 1849 it commenced the publication of its "Papers and Proceedings."

In 1854 the Legislative Council of Tasmania by "The Royal Society Act" made provision for vesting the property of the Society in trustees, and for other matters connected with the management of its affairs.

In 1855 the name of the Colony was changed to Tasmania, and the Society then became "The Royal Society of Tasmania for Horticulture, Botany, and the Advancement of Science."

In 1860 a piece of ground at the corner of Argyle and Macquarie streets, Hobart, was given by the Crown to the Society as a site for a Museum, and a grant of £3000 was made for the erection of a building. The Society contributed £1800 towards the cost, and the new Museum was finished in 1862.

In 1885 the Society gave back to the Crown the Botanical Gardens and the Museum, which, with the collections of the Museum, were vested in a body of trustees, of whom six are chosen from the Society. In consideration of the services it had rendered in the promotion of science, and in the formation and management of the Museum and Gardens, the right was reserved to the Society to have exclusive possession of sufficient and convenient rooms in the Museum for the safe custody of its Library, and for its meetings, and for all other purposes connected with it.

In 1911 the Parliament of Tasmania, by "The Royal Society Act, 1911," created the Society a body corporate by the name of "The Royal Society of Tasmania," with perpetual succession.

The object of the Society is declared by its Rules to be "the advancement of knowledge."

His Majesty the King is Patron of the Society; and His Excellency the Governor of Tasmania is President.

VICTORIA

The Royal Society of Tasmania

Papers and Proceedings, 1932

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Papers
of
The Royal Society of Tasmania
1932

ABORIGINAL ROCK CARVINGS IN TASMANIA.

Part II.

By
A. L. Meston, M.A.

Plates I.-IV.

(Read 10th October, 1932.)

On the 13th of July last year I read a paper before the Society in which I described some aboriginal rock carvings on the Mersey Bluff, near Devonport. In this paper I propose to describe another series of aboriginal carvings. These I discovered in December, 1931, on the west coast, 90 miles, as the crow flies, from those at Devonport.

These carvings are not only intensely interesting in themselves, but are important, in that they provide further evidence of aboriginal art. In many respects they differ from those near Devonport. The latter are in diabase, are cut on horizontal faces, and in the main exist as units; whereas the west coast carvings are in a friable calcareous sandstone, are cut without any respect to the surface plane, and are massed together, sometimes in rude geometric designs.

Twelve miles south of Cape Grim there projects into the sea a massive diabase headland, which, although only a little more than 500 feet high, rising, as it does, out of a country of low elevation, is so prominent a feature that it is called Mount Cameron West. Two miles north of this landmark are the two outcrops of friable calcareous sandstone, 150 yards apart, small in area, and of low elevation, on which the carvings are found. The rock is soft and easily worked, but hardens on contact with the air. In consequence of its friable nature many of the carvings are badly weathered, and all show marks of erosion. The circle,

a common form at Devonport, is here the motif of most of the designs. Here, however, are found features absent from the Devonport carvings, namely, groups of three straight lines roughly parallel with one another, and rows of indentations.

At the southern outcrop the natives have made use, not of the main mass, but of two detached blocks lying at its foot. On these, shown on Plate I., are the most striking of the carvings, which are clearly visible more than 200 yards away. Plate IV. shows the method employed in making them. Indentations or punch-marks are first made close together, apparently with a quartzite burin or punch, driven by a stone used as a hammer; then a continuous line is made by connecting up the holes so formed. A close search for any tools that may have been used in the work resulted in my finding a chisel-shaped piece of quartzite and another pointed stone implement admirably adapted for executing the designs. There is, of course, no evidence except proximity to show that these may have been used.

The northern outcrop, larger than the other, is just a mass of carvings. The cliff face and detached slabs, no matter at what angle they lie, provided there is a smooth surface, have provided a medium for the artist. In the main mass there is a shallow cavern, upon the roof of which, quite out of reach of one standing below, two circles have been carved. These are shown in Plate II., Fig. 1. One mass of approximately 12 feet square, tilted at an angle of about 60 degrees, is entirely covered with circles and concentric circles, some badly weathered, others in a good state of preservation. Some of these are shown in Plate II., Fig. 2.

This district, like the Bluff at Devonport, was a frequent haunt of the natives. The whole area is littered with shells, the remnants of their feasts, and with the cores and rejects from the manufacture of their stone implements. When the aborigines roamed along this shore it was a beautiful spot. Sand-banks covered with boobyallas and other native shrubs extended along the whole area, while immediately behind them were park-like spaces, the pasture ground of mobs of kangaroo. Here they found a place which lay open to the sun, and yet afforded them shelter from the bitter winds. The reefs nearby provided an ample supply of shellfish; the lagoons behind the beach teemed with black swan and wild duck; and the district

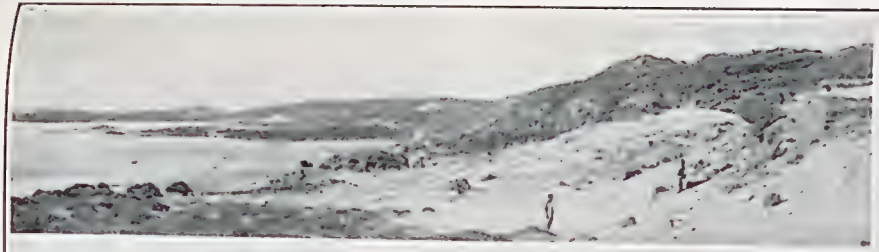

Fig 1.

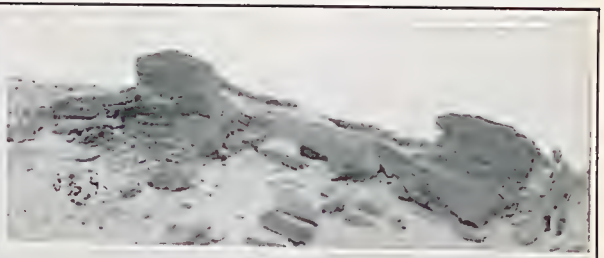

Fig 2

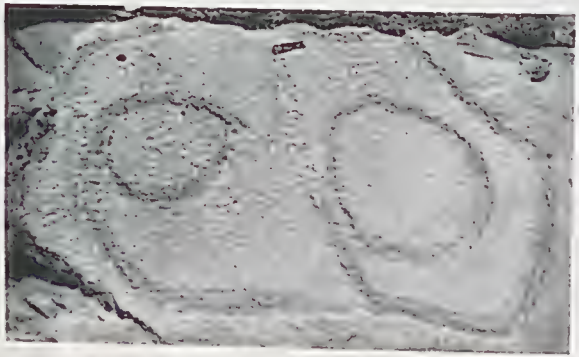

Fig 3

Fig 4

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Fig. 1.

Fig. 2.

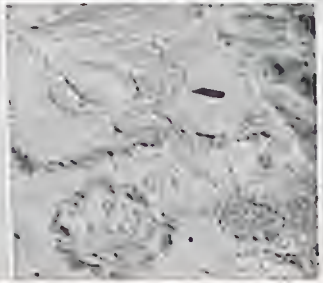

Fig. 3.

Fig. 4.

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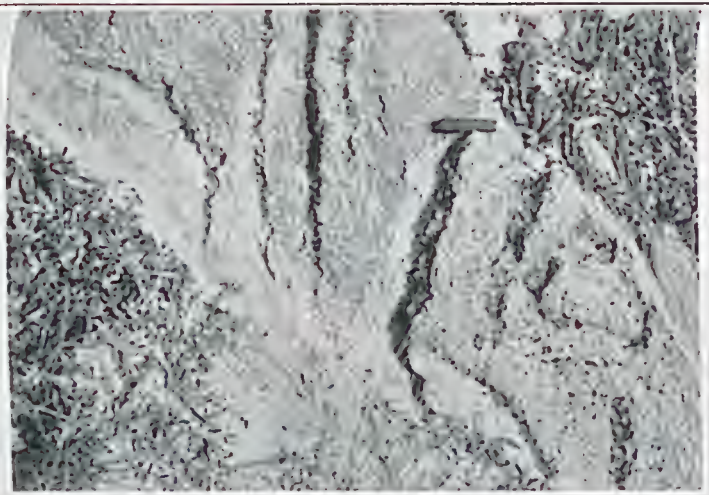

Fig. 1

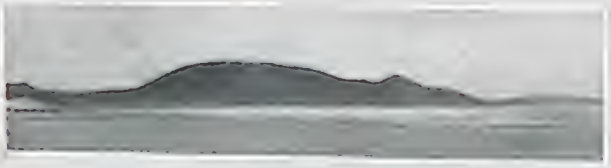

Fig 2

Fig 3

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VICTORIA.

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abounded with wallaby, kangaroo, and opossum. Even to-day, although vast sand-blows, begun by cattle breaking down the banks and allowing the wind free play, have destroyed the face of the country in places for miles inland, the lagoons which are left still teem with wild fowl, and kangaroo, wallaby, and opossum are plentiful in the neighbourhood.

The occurrence of this small isolated sandstone outcrop, totally different in structure from the surrounding rock masses—quartzite to the north, diabase to the south—is remarkable. One feels that to a people in whose lives stones and rocks played such an active part, such an occurrence would be significant. Codrington, who spent twenty-five years in Melanesia, speaks of the superstitious regard for stones commonly shown by the Melanesians, and points out that "stones as they naturally lie," because they strike the fancy as being out of the common, are frequently the object of veneration. It may have been so here in Tasmania, for the opinion of many of the leading anthropologists is that our aborigines were of Melanesian origin.

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EXPLANATION OF PLATES.

PLATE I.

Figure 1.—A general view of the coastline in the vicinity of the carvings, looking north. The figures 3 and 4 on this plate are on the outcrop in the foreground on the extreme right.

Figure 2.—A view of the southern outcrop and both carvings, one near the human figure, the other at the foot and to the right of the extreme mass.

Figure 3.—This design is on the slab at the left of Fig. 2. When discovered the lower edge was covered with sand. It consists of an irregular figure 102 cms. long and 77 cms. wide, with a median line forming two lobes. The left lobe encloses an irregular circle with diameters of 30·5 cms. and 25·5 cms.; the right lobe encloses one with diameters of 44 cms. and 35·5 cms. The grooves are from 3·25 cms. to 4 cms. wide and 2·5 cms. deep. The edges are abraded by weathering.

Figure 4.—This is the most elaborate of the designs, and is on the slab near the human figure shown in Figure 2. A full description appears under Plate IV.

Plate II.

Figure 1.—A general view of portion of the northern outcrop, showing the shallow cavern and a group of carvings in the left foreground.

Figure 2.—This rock face, 3 metres high, looking to the south, is completely covered with circles, most of them badly weathered. This figure shows the two carvings that are best preserved. The lower one consists of two concentric circles, the outer of which has a diameter of 71 cms., the inner of 53·4 cms. Inside the inner ring are two small circles; the left-hand one, 14 cms. in diameter, is made up of 12 punch-marks not connected, which surround a circular boss 9 cms. in diameter; the right-hand one is more irregular, and has diameters of 19 cms. and 11·5 cms. The upper carving is a circle of 46 cms. in diameter. The grooves of both these circles are 5·4 cms. wide. To the right of the lower of these carvings, and not distinctly shown, is an irregular circle with diameters of 46 cms. and 40·6 cms., enclosing a smaller irregular circle with diameters of 17·8 and 14 cms. Another distinct circle on this rock face is 33 cms. in diameter, while another irregular one has diameters of 58·4 cms. and 49·5 cms. Not only the southern face, but the whole mass, wherever it is clear of sand, is covered with circles, most of them badly weathered.

Figure 3.—With the exception of the lower left-hand carving, these, while quite distinct, are not so bold in out-

line as the rest. The total length of the irregular carving near the pocketknife is 57·2 cms. The irregular circle enclosed has diameters of 21·5 cms. and 17·8 cms. Close to this is an oval with diameters of 15·2 cms. and 11·4 cms. The wide grooved circle at the bottom has diameters of 31 cms. and 28·5 cms., while the narrow grooved circle at the bottom is 15·2 cms. in diameter. At the head of the irregular-shaped carving, but not shown in the photograph, are three straight lines, 29·2 cms., 33 cms., and 33 cms. in length respectively, meeting a fourth straight line at right angles.

Figure 4.—These carvings are on the rock that is shown as being measured in Fig. 1 of this plate. The slab is 102·9 cms. wide, 139 cms. long. Only seven of the ten circles carved on it are shown in this photograph. In the top right-hand corner are three straight lines, 21·5 cms., 22·8 cms., and 30·5 cms. in length respectively, the shortest being at the top. The circle near them has diameters of 36 cms. and 27·9 cms. To the left of this, but outside the scope of the photograph, is another with diameters of 31·7 cms. and 26·5 cms; and immediately below it, but also not shown, is another with diameters of 20 cms. and 15·2 cms. From left to right in this photograph the diameters of the circles are 22·8 cms. and 20·3 cms.; 27·9 cms. and 26·7 cms.; 21·5 cms. and 18·9 cms.; 25·4 cms. and 22·8 cms.; 21 cms. and 16·5 cms.; 25·4 cms. and 20·3 cms. To the right of the lowest one is another of 30·5 cms. and 22·8 cms., but only a small part of it is seen in the photograph. The grooves in these circles vary from 5·1 cms. to 3·8 cms.

Plate III.

Figure 1.—This is a nearer view of the slab shown in the left-hand corner of Plate II., Fig. 1, and shows how the sand has encroached on the carvings. Note the straight lines.

Figure 2.—A view of Mount Cameron West from the site of the carvings.

Figure 3.—A nearer view of the carvings on the roof of the shallow cavern. These are not so expertly done as those shown on the rock face (Plate II., Fig. 2). The contrast is remarkable. The lowest of the three circles distinctly shown has diameters of 30·5 cms. and 22·8 cms. The whole of this rock mass is covered with circles almost obliterated by weathering.

Plate IV.

The total length of the slab which is entirely covered with the design is 177·8 cms., its greatest width is 142·25 cms., its least width 46 cms. The large irregular circle on the right is broken away at the top and bottom edges, and a large crack, clearly visible in the photograph, has developed, threatening to destroy the mass still further. Its greatest diameter is 91·5 cms., its least 73·6 cms. It encloses another almost perfect circle, 45·7 cms. in diameter, and a number of indentations in rows above the circle. The top row contains 16 indentations, the second 15, and the third 15. Above the fifth in the top row is a single indentation, while below the second in the bottom row is a line of three. To the left of this large circle are three vertical rows of indentations: the right-hand row consists of 19, the middle 11, the left-hand 10. Immediately to the left of these rows is an irregular barred circle with diameters of 55·9 cms. and 46 cms., containing two isolated indentations. Below the vertical row of indentations is another irregular circle with diameters of 35·4 cms. and 31·7 cms. In the bottom left-hand corner of the slab are two small irregular circles, the right-hand one with diameters of 12·7 cms. and 15·2 cms., the left-hand one 15·2 cms. and 16·5 cms. Above these lies a pear-shaped figure 25·4 cms. by 20·3 cms., and contiguous with it is another irregular figure 22·9 cms. by 11·4 cms. in part concurrent with the barred circle. These two figures make an irregular 8 with a projection from the middle. The top outer edge of the 8 is continued by a curved line of indentations, 13 in number, which is terminated by a horizontal row of four indentations. At the top left-hand corner of the slab is an irregular circle with diameters of 25·5 cms. and 24·8 cms. To the right of this lies another irregular barred circle with diameters of 46 cms. and 28 cms., the right lobe containing two indentations, the left, one. A single indentation lies between these two figures. The width of the grooves throughout the design varies from 7·6 cms. to 2·5 cms., the depth is 2·5 cms., and all are abraded by erosion. At the toe of the slab may be seen part of a circle which has broken off, and below it lie several other fragments that have broken away.

THE OCCURRENCE OF THE FRESHWATER POLYZOAN, *PLUMATELLA REPENS* (VAN BENEDEN), IN TASMANIA.

By

V. V. Hickman, B.Sc., B.A., and E. O. G. Scott.

Plate V.

(Read 5th April, 1932.)

The present note records for the first time the occurrence of *Plumatella repens* in Tasmania. This widely distributed European species has already been found in Queensland, New South Wales, Victoria, South Australia, and New Zealand. It is not surprising, therefore, that its distribution should also extend to this State.

Our specimens were collected from a small creek which runs through the Punch Bowl Reserve, near Launceston, and we have met with it also in a creek running through Harland Rise, the estate of Mr. H. Dowling, near Evandale. The Polyzoan seems to flourish during the months October, November, and December. It is during this period that the creeks are running slowly and well stocked with algæ. The colonies of polypides are generally attached to the undersurface of stones and sunken logs, and a single colony may cover an area of 100 square centimetres.

The chitinous ectocyst is transparent when newly formed, but soon becomes brown and almost opaque, owing to foreign particles which adhere to its outer surface. The branching of the colony is characteristic of the species.

In January the creeks become almost stagnant, and the polypides die, leaving the brown ectocyst still attached to the surface on which the colony was growing. This somewhat disintegrated ectocyst generally contains a number of statoblasts.

The typical statoblast of *Plumatella* has the form of a more or less opaque ellipsoid germinative body, ringed with a semi-transparent annulus of air-cells, the float, which assists in dispersal; the whole structure exhibiting a rough resemblance to the samara of the common elm. As is well known, the statoblasts, even when derived from a single

polypide, manifest considerable diversity in size, colour, and details of structure, the variation being largely, but apparently not entirely, in accordance with the state of development.

The following records of dimensions, obtained by the measurement of ten examples, mounted in balsam, give some idea of the general variability in size:—

(*a*) Total length: maximum, 677μ; minimum, 377μ; average, 478·3μ

(*b*) Total breadth: maximum, 382μ; minimum, 274μ; average, 324·5μ.

(*c*) Length, excluding float: maximum, 447μ; minimum, 250μ; average, 341·0μ.

(*d*) Breadth, excluding float: maximum, 329μ; minimum, 202μ; average, 236·9μ.

The ratio of total length to total breadth ranges, in these ten examples, from 1·33 to 1·78, and has an average value of 1·47.

The central germinative body is brown or red in colour. In statoblasts found in the living colony, it is generally more or less granular in structure, the granules often exhibiting a tendency towards segregation into irregular polygonal groupings, which, exceptionally, may become fairly regularly hexagonal. Occasionally, presumably when development is well advanced, there may be observed about half a dozen concentric elliptical rings, surrounding a dark central spot. The body is bounded, in examples taken from living polypides, by a well-defined, apparently structureless amber-coloured ring, having an average width of 6 or 8 microns. A layer of hexagonal cells, apparently continuous with the cells of the float, usually invests the germinative mass, either partly, forming a peripheral annulus, commonly from 2 to 5 cells wide, or, especially in fully mature examples, wholly.

The float, which has the form of a thin, more or less transparent ring of slightly elongated hexagonal air-cells, is typically elliptical, or somewhat panduriform, in outline. It may be colourless, slightly greenish, pale-yellow, or, in older statoblasts, golden. It is, in general, fairly symmetrically disposed round about the germinative mass, normally extending further beyond it along the major than across the minor axis. Occasionally the lateral portions of the float are not in evidence at all when the statoblast is

A Colony of *Plumatella repens* (van Beneden).

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viewed from above or below, the whole structure then having the form of a central ellipsoidal mass, with a bluntly rounded wing projecting for a distance of about 100μ from either end. At times the periphery of the ring of air-cells exhibits a more or less pronounced rim, a single cell thick. In the so-called "sessile" statoblasts the float is absent. Two such floatless statoblasts were found to measure, when mounted, 433 by 350μ, and 447 by 338μ, respectively.

EXPLANATION OF PLATE.

A colony of *Plumatella repens* (Van Beneden), growing on underside of a stone from the Punch Bowl Creek, Launceston.

A NEW PROTOZOAN PARASITE FROM A BDELLID MITE.

By

G. Bourne,
Department of Biology, University of Western Australia.

One Text Figure.

The parasite here described was found occurring in one of four Bdellid (*Biscirus intermedius*) mites from Tasmania. The mite containing the parasite was kindly placed at my disposal by Mr. H. Womersley, A.L.S., F.E.S.

The parasite was present in the abdominal region of the mite, the exact position being shown in the figure. It was reniform, and was approximately one-eighth the size of the animal.

The general appearance was rather Sarcosporidian in nature, under low power being somewhat granular. Under higher powers no sign of spores could be observed, the granules appearing purely protoplasmic in nature.

Attempts were made to stain the parasite *in situ* with borax carmine. The protoplasm of the mite was, however, more chromophilic than that of the parasite, or there may have been a stain resistant wall around the parasite; in any case, it was quite obscured by the deeply staining mite cytoplasm.

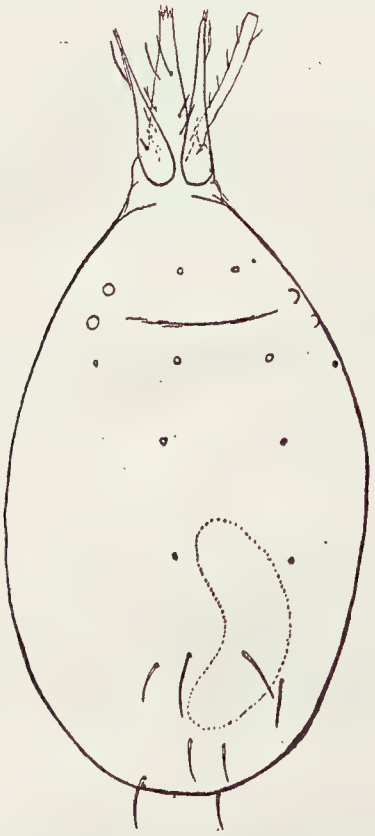
The abdomen of the mite was dissected off, and with the aid of a microscope and fine needles the parasite was removed from the abdomen.

Freed from the surrounding host tissues, the parasite was observed to be stained a light pink by the borax carmine, the granulations of the cytoplasm not indicating any chromophilic tendency, and even when the parasite was broken there was no indication of contained spores.

It was at first thought that this parasite may be an egg, but it is at least twice as large as any Bdellid egg known, and, in any case, the eggs of these mites are invariably

perfectly spherical, produced in greater numbers than one at a time, and covered with numerous clavate hairs. There was no signs of hairs on the parasite.

The possibility of the parasite being some object that the mite had ingested was also considered, but this was precluded by the fact that it was not within the alimentary canal, and appeared to be free within the body cavity.



Drawing by Mr. H. Womersley, A.L.S., F.E.S., of the mite *Biscirus intermedius* (*Sig Thor*), showing the parasite dotted in position in the abdominal portion of the mite. (Times 55.)

It is unlikely that it would be the egg of invading multicellular parasites such as Nematodes, since, for one of these to lay an egg this size it would need to be at least as large as the mite.

Systematic Position of the Parasite.

The parasite described above does not appear to be represented in the literature, but is obviously Protozoan in nature, a member of the Sporozoa.

The only group into which this parasite could be made to fit is that known as the Haplosporidia, which Wenyon considers may be fungoid in nature. Wenyon states in connection with the Haplosporidia that "they are found in aquatic Invertebrates and Fish." Sig Thor has, however, found small bodies in mites on the Continent which he has referred to Haplosporidia; his parasites are, however, very different from that here described.

The parasite is undoubtedly different from any other recorded type, and would appear to be somewhat akin to the Sarcosporidia before they begin to divide up into spores and simply possess granular cytoplasm. The position in the host (free in the body cavity) would indicate some connection with the Haplosporidia. It is probable that at a later stage the parasite would divide up to form spores, and that the stage which has been described is very young. From the fact that only one mite in four from the same locality, and no other of some hundreds of Australian Bdellid mites examined by Mr. Womersley have show the presence of this parasite, and no other worker appears to have observed it, it is apparently quite rare.

In view of the lack of knowledge of the spores of this parasite, it is difficult to refer it to its exact systematic position, although I am placing it tentatively in the Haplosporidia. I feel, however, that it will eventually require a new order of the Sporozoa to receive it; this could not be done with the material so far examined, and until a more detailed knowledge of the various forms of the parasite during its life history is available.

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ACKNOWLEDGMENT.

I am greatly indebted to Mr. H. Womersley, A.L.S., F.E.S., for advice in connection with this paper and for kindly supplying me with the illustration.

A NEW TASMANIAN TERRESTRIAL ORCHID.

By

W. H. Nicholls.

(Communicated by Clive Lord.)

Plate VI.

(Read 9th December, 1932.)

Caladenia echidnachila, n.sp.

Planta terrestris, gracilis; habitu Cal. Patersonii, R. Br.; folium linearo-lanceolatum, hirsutum, canaliculatum; flores 1 *vel* 2, *majesticuli; lutei et rubri; ovarium densissime-hirsutum; perianthii-segmenta sub-aequalia, lineara et oblongo-lanceolata, filamentosa, glandulosa, patentia, pendula; caudæ* 4-5 *cm. longæ; sepalum-dorsale erectum, incurvum; labellum breviter unguiculatum, ovatum, apice filamentosum, glandulosum, obscure tri-lobatum; callis anguste-linearibus et robustiusculis, sex-seriatis, prope medio terminantibus; columna circiter* 1·3 *cm. longa, erecta, incurvata; anthera brevis.*

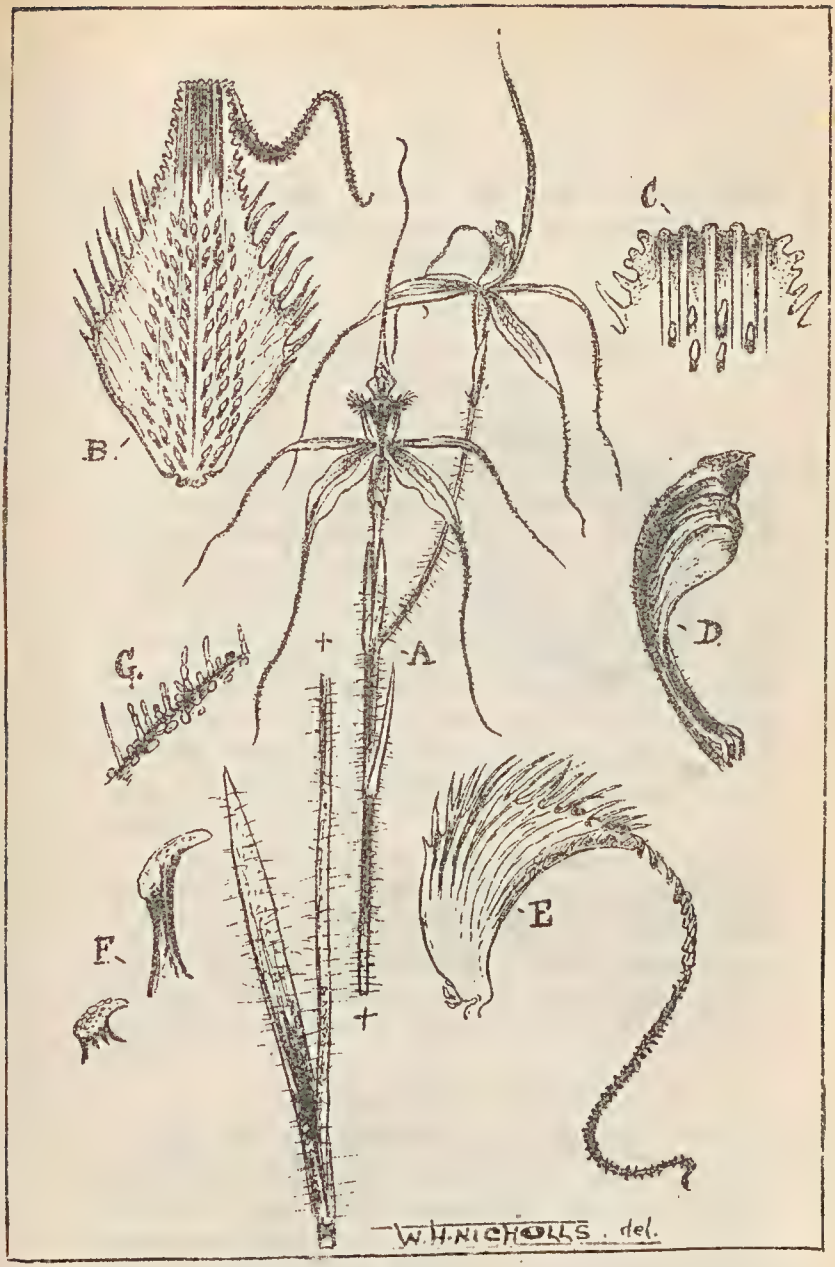
[A slender, moderately hairy species, with the habit of *Cal. Patersonii*, R. Br.; leaf hairy, linear-lanceolate, channelled; flowers 1-2; yellowish with crimson veinings and darker filamentous-glandular caudæ to the segments; caudæ about 4-5 cm. long; ovary covered with dense glandular hairs; lateral sepals and petals narrow-lanceolate, spreading, pendant; with three narrow longitudinal, central lines; sepals and petals about equal in length, petals narrower than the sepals; dorsal sepal erect, incurved; labellum erect, on a small movable claw, ovate-lanceolate, acuminate, yellowish with pale, diffused crimson veinings; tip wholly dark crimson, lower part of lamina erect, with entire margins, then deeply fringed; anterior margins serrulated; apex produced into a long, tapering filamentous-glandular process, fully twice as long as the broad portion of lamina (total length of labellum, 3·5-4 cm.); calli fleshy, slender, clavate, golf-stick type, in 6 rows, forward calli short and stout, not extending beyond the bend; five conspicuous longitudinal ridges continuing from between the rows of calli towards the tip; column erect, incurved about 1-3 cm. long, widely winged above; 2 yellow sessile glands at the base; anther with a short point.]

The above description is based on two specimens forwarded by Archdeacon Atkinson, and discovered by his sister, Miss H. M. Atkinson, of Lenah Valley, Hobart. The habitat is Lenah Valley. The labellum is unique within the genus *Caladenia*, R. Br.; and has been likened to the "long worm-like extensile tongue" of the "native porcupine" (*Echidna aculeata*).

This interesting species is closely related to *Cal. Patersonii*, R. Br., but differs from that well-known "spider" in all its variations, and also from all other closely related species, chiefly in having a long filamentous apex to the labellum. Flowering in October.

It is a remarkable addition to the Flora of Tasmania.

The type specimen is in the Tasmanian Museum, Hobart.



Caladenia echidnachila, n.sp.

A. A typical plant.
B. Labellum from above (spread out).
C. Fore part of labellum-lamina, showing ridges.
D. Column from side.
E. Labellum from side. Note character of marginal fringe.
F. Calli from the labellum-lamina.
G. Glands from the perianth-segments. (Figures of details variously enlarged.)

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NOTE ON THE ORIGIN OF THE GREAT LAKE AND OTHER LAKES ON THE CENTRAL PLATEAU.

By

A. N. Lewis, M.C., LL.D., M.H.A.

Plates VII.-XX.

1. Introductory.

The Central Plateau of Tasmania is a pivotal feature of Tasmanian physiography and industrial enterprise, but has been rather neglected by geologists. The topography of the plateau has been well known since the earliest days of the pastoral industry, and several general accounts are available (see, e.g., the references at the end of this paper). Much of the plateau is still difficult of access, although the roads to the fishing resorts and engineering works have made considerable sections far more accessible than was the case thirty years ago. A current, though erroneous, opinion, that the surface of the plateau is covered with uniform dolerite, is not glaciated, and carries little interesting vegetation, has been largely responsible for a seeming lack of interest.

I feel that it will be many years before I am in a position to offer a complete geological map of the plateau, in view of the number of years that have elapsed since I first commenced this task, but I also feel that I should present these notes to amplify the recorded descriptions of this most important region, and to correct some errors which have worked confusion in general statements of Tasmanian geology.

2. The Central Plateau.

The area under discussion is an accepted geographical feature bounded by lines connecting Cradle Mountain, Dry Bluff, Miller Bluff, Table Mountain, and Mount Olympus, with the Eldon Range, Mount Gell, the King William Range, and Black Bluff as outliers, an area of some 2000 square miles, averaging 3000 feet in elevation, and with marked escarpments to the lower lands below. The best

description is to be found in R. M. Johnston's "Geology of Tasmania" (Johnston, 1888), although the Denison Range should not be included. Further general description by me must be excluded for lack of space.

3. Previous Accounts and Opinions.

General descriptions such as those contained in Breton's account of a trip from Cressy to the Great Lake (Breton, 1846), and in Geoffrey Smith's account of his trip from Bothwell to the Great Lake and thence to Lake St. Clair (Smith, 1910), are interesting, but throw no direct light on the geology of the area. Accounts published in Strzelecki's and R. M. Johnston's geologies (Strzelecki, 1845; and Johnston, 1888) are to such an extent based on discarded theories as to be now only of historical interest. Colonel Legge's work (Legge, 1902, 1903, and 1904) is of vital importance to the geographer, and its detail must be of value for all time as a basis for any work on the Great Lake; but, again, it is not directly a geological account. These facts limit the previous accounts of the geology of the region to a very small scope.

Most of the western edge of the plateau has been very fully described and mapped—the Cradle Mountain-Barn Bluff district by Dr. Benson (Benson, 1916); the Pelion district, immediately to the south, by Mr. McIntosh Reid (Reid, 1919); and the Lake St. Clair district by Mr. Clemes (Clemes, 1924). This leaves only the Du Cane Ranges untouched in that section. A corner of the eastern edge, round Lake Sorell, has been mapped by Mr. Nye (Nye, 1921). As to the remainder of the plateau, the great area of upland moors, lakes, and tiers, there is no detailed geological account, and I regret that I can contribute so little to remedy this deficiency.

In 1893 the late Mr. R. M. Johnston said: "I have, from long observation, arrived at the conclusion that the larger lakes on the higher levels of the greenstone plateau—such as Lake St. Clair, Lake Sorell, Lake Echo, Lake Arthur, and Great Lake, together with innumerable lakelets and lagoons on the upper levels—have been mainly determined by the original irregularities of the surface, produced partly by the anastomoses of successive flows of greenstones during their eruption, and partly by the unequal contraction due to lack of homogenity of the cooling surfaces of the more massive horizontal flows of greenstone magma . . . . ."

General Locality Plan—Scale 1 inch to 8 miles.

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(Johnston, 1893). Such view depended on the idea that the dolerite (greenstone, diabase) was eruptive. This theory has long since been discarded, but Mr. Johnston's explanation of the origin of the large lakes has not been revised. Mr. Johnston, in the same paper, discounted the suggestion that these lakes may be of glacial origin. Speaking only of Lakes Sorell and Crescent, Mr. Nye said, in 1921: "These two lakes occupy depressions in the diabase formed by the denudation of the Trias-Jura sediments which once covered this part of the plateau." And, again: "Not the slightest evidence of any Quaternary glaciation is to be found, and it is concluded that this part of Tasmania escaped the glaciation of the above period, so common in the western part of the State" (Nye, 1921). About the same time Mr. Loftus Hills, then Government Geologist, stated to me that, in the course of an investigation of the site of the Great Lake dam at Miena, he could not find any trace of morainal deposits at the outlet of the lake. Colonel Legge recognised the effect of present-day ice on the Great Lake, but did not comment on the possibility of a glacial origin. In passing, I desire to call attention to some remarks on the general geology of the plateau made by the late Mr. Tom Stephens in 1899 (Stephens, 1899), which remarks are fully borne out, as far as they go, by my observations. Reference should also be made to the fact that since 1912 the Journals of Parliament (Tasmania) contain an annual report of the Hydro-Electric Department, and of the hydrometric survey conducted by that department for some years, with plans, some sketch-maps, and photos. These provide a history and description of the engineering operations of the department and some account of the Great Lake-Ouse area. No direct geological information is contained in these reports.

4. Geology of the Plateau.

The Central Plateau consists of a base of Pre-Cambrian to lower Palæozoic rocks, covered unconformably by Permo-Carboniferous and Triassic sediments, deposited in a manner which clearly shows the existence of an undulating topography at the commencement of the deposition and a gradually sinking sea-floor. The older rocks appear from the vicinity of Quamby Bluff, westward and southward to the vicinity of Mount Arrowsmith, but are not exposed under the more recent series on the east and south of the plateau. The whole sedimentary series was penetrated by dolerite at the close of the sedimentary phase (probably

middle Triassic), but the dolerite, as is usually the case, particularly invaded the upper coal measures and sandstone rocks of the Triassic period. I do not think that the dolerite can be regarded as one sill. Detailed mapping will probably show many irregular transgressive masses, with large horizontal sills intruding outwards in one or more directions. Many of the more spectacular escarpments, such as Table Mountain and Dry Bluff, represent the passage of fault-lines through such sills, and, to the westward, in the area in which lower-Palæozoic and pre-Cambrian rocks are now seen at an elevation of 2000-4000 feet, the sill extensions appear to have been more pronounced.

Dolerite, massive or as accumulations of talus, occupies the greater part of the surface of the plateau, but sedimentary rocks (Triassic sandstones and Permo-Carboniferous mudstone) appear on the boundary escarpment of the Western Tiers from an elevation of about 2800 feet downward, in most of the valleys draining the plateau and in many places on the plains of the higher elevations. Sedimentary and metamorphic rocks compose many of the prominences towards the north-west corner, even up to elevations of 4000 feet (see Plate XXXVI.: "Coal Resources of Tasmania"; and Reid, 1919, Plate IV.). Much of the surface of the plateau, particularly on its southern slopes, is covered with olivine basalt lava-flows assigned to Tertiary age, and, in places, these overlie and protect Tertiary river conglomerates.

The whole mass of the plateau is marked with faults, traversing all rock series. No information is yet to hand as to the age of this faulting, or as to its relationship with the general uplift of the plateau. Efforts to trace the fault-line usually end at a spot where, apparently, one dolerite mass is faulted against another, and information as to general trend lines and other important data which will be provided by accurate mapping must await the completion of this task. There is little doubt in my mind that many of the minor features of the plateau, such as escarpments, tiers, and river valleys, are largely controlled by fault-lines. There appears to be a general tilting of the plateau mass from the north-west downward towards the south-east, but this is probably the results of a complicated series of step faults rather than a bodily tilting of the whole mass. Evidence exists that the uplift occurred earlier in the north-western area than in the south-eastern, and that the move-

[*A. N. Lewis, Photo.*

I. *Lake Sorell* from Interlaken. Mollie York's Night Cap in background.

[*A. N. Lewis, Photo.*

II. *The Western Tiers,* looking south-east from edge of tiers, north of Arthur Lakes, across gorge of Lake River.
Miller Bluff in background. Mount Patrick in background to right.

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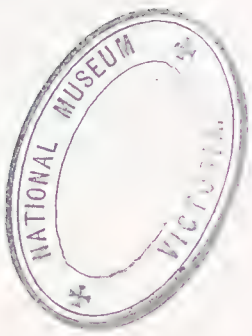
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ment progressed south-easterly in large separate segments, becoming less marked during the progress.

Of the later sedimentary series, the upper marine mudstones are common round the base of the Western Tiers, in the valleys of the Mersey, Forth, and Ouse, and elsewhere round the south and east of the plateau. Lower coal measures have been reported as occurring at Bashan, and lower marine limestones high in the gorge of the Meander. Probably other occurrences will be found when the Western Tiers are mapped. Ross sandstones occur under the dolerite in almost every exposure of the bottom of the sills, and also on top of that rock in many places. Felspathic sandstones and shales occur in a few localities.

The geology of the plateau corresponds remarkably to that of adjoining areas, e.g., the Midlands or Bothwell-Hamilton district. The higher ridges are composed of dolerite, and stand out as long, narrow, and usually flat-topped lines of hills. In between lie rolling plains, covered largely with sedimentary rocks and basaltic lava-flows, and broken by lesser hillocks, often of dolerite. No one, when looking over any of the plains of the upper levels of the plateau, can help being struck most forcibly with the remarkable resemblance of that landscape to the Midlands plain. All the evidence at present to hand points to the conclusion that the Central Plateau is geologically a continuation of the Midlands, and that both these regions have been subject to identical physiographic influences during the greater part of the cycle in which the plains have been developed.

The more I consider the development of such features of Tasmanian physiography as the Central Plateau and other similar elevated blocks, the stronger I adhere to the general view as to their origin, already expressed (Lewis, 1926 and 1927), namely, that we see a post-dolerite (probably late Tertiary) peneplaination or semi-peneplaination, followed by the uplift of the plateau blocks to the position in which we know them. It is difficult to imagine the Western Tiers as anything other than a remarkable fault scarp. The present drainage can hardly have been responsible for the topography of the upper levels of the plateau. The gorges of the Forth, Mersey, Meander, Liffey, and Lake Rivers flowing north, and those of the Ouse and Derwent flowing south, are very recent features; but the elevated plateau mass shows features of a cycle previous to that initiated by the uplift. The degree of post-glacial river erosion

apparent in all these gorges is such as to preclude the possibility of the existence of the plateau features since the time of the dolerite intrusions. I regret that more attention has not been accorded to my explanation of Tasmanian physiography in the last six years, as, until this problem is settled, geographical work in general in this State must run the risk of being based on a fallacy.

The fuller examination which I have been able to give to the Central Plateau than has been possible to other workers, aided by experience gained elsewhere, enables me to say with certainty that the whole of the upper levels (above 2400 feet on the western side, 3000 feet on the eastern) were subject to ice-cap conditions during the Pleistocene ice age. This aspect will be more fully discussed later. The term "ice-cap" as used in this paper is to be taken as meaning an accumulation of ice on a mountain possessing a wide expanse of comparatively level surface. The features of the ice in this area show merely the characteristics of valley glaciers, with some modifications due to the plateau conditions, and the term is not used as indicating the features of a Continental ice-sheet.

5. Lake Sorell Area.

This district has been sufficiently described by Mr. Nye (Nye, 1921). The range forming the elevated edge of this plateau, and extending from Molly Yorke's Night Cap through Mount Franklin, and the Old Man's Head to Table Mountain, averages 3500 feet above sea-level, and was well above the snow line during the period of maximum intensity of the ice age. Ice appears to have moved from good névé collecting grounds in this high land. Glacially transported erratics are sparsely scattered over the flat and swampy course of the Mountain River, which enters the northern side of Lake Sorell (2800 feet). (This is just outside the area mapped by Mr. Nye.) Ice clearly moved southwards into the plain now occupied by the lake through one or more of these valleys. Suspicious, although vague, evidence exists of slight movements north-westward from Table Mountain towards Lake Crescent, and eastward from the Alma Pass tier towards Lake Sorell. Nowhere have I traced obvious morainal deposits except in the valley of the Mountain River, but it is quite possible the lakes now conceal the locality of the termination of the ice. Nevertheless, the area was subjected to Pleistocene glaciation to some extent.

[*A. N. Lewis, Photo.*

III. *North Arthur Lake.* Mount Patrick in background. Morainal deposits in foreground.

[*A. N. Lewis, Photo.*

IV. Rudimentary Cirque at head of the Little Lake—*Great Lake.*

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6. Arthur Lakes Area.

These lakes lie in a broad, flat plain at an elevation of 3090 feet, and separated from the Lake Sorell plain by Alma Tier (3500 feet). At the head of the plain stands Brady's Lookout (4497 feet), and high tiers surround the lakes, except for a small space to the north and a wider opening to the south. The Sandbanks Tier (3500 feet) separates this area from the Great Lake district to the west, and a second ridge runs southwards round the east and south-east of the area through Mount Patrick to Mount Penny (3792 feet). The plain feature extends southwards over St. Patrick's Plains, The Steppes, Lagoon of Islands, and Lake Leacock, and disappears without further elevation in the valley of the Shannon.

A considerable quantity of Ross sandstone occurs over the site of the southern Arthur Lake, in the valley of the Lake River, and westward under and round the southern end of Sandbanks Tier, to the western shore of the Great Lake. Basalt covers much of St. Patrick's Plain and the eastern slope of Barren Tier. On the north-eastern slopes of the lastmentioned feature, overlooking the Great Lake, there are outcrops of Tertiary river conglomerates. Ilmenite sands occur on the floor of Arthur Lakes.

It is probable that the whole of this area was covered by ice during the ice age, but I have not traced direct evidence south of a line between Mount Penny and the southern end of the south Arthur Lake. Northward of this line the evidence is plentiful. The ridges south of Brady's Lookout have been swept clear of loose boulders, and glacial erratics are common over the surface of the plain. Little Lake, to the north of Arthur Lakes, and only 100 feet higher in altitude, lies in terminal moraine country, and the shallow valley through which its overflow reaches Arthur Lake is strewn thickly with erratics of both dolerite and sandstone. Similar, although less plentiful, evidence exists in the area of the plain through which Tumbledown Creek flows, on the neck of land between the two Arthur Lakes, and in extensive fields bordering Sandbanks Tier on the south-east. It is probable that the Arthur Lakes are dammed by morainal material, although I cannot assert this with any degree of certainty. The more prominent ridges of the tiers and larger hills show the typical shattering effect of intense nivation due to protrusion from the ice as nunataks.

The ice appears to have accumulated on the slopes of the flanking ridges, and to have moved in a broad shallow sheet southwards and south-eastward over the area. In a few isolated places it moved northwards and fell over the edge of the plateau. I have not determined the maximum extension. It is possible that ice covered in one sheet the whole area southward to the Steppes, Lagoon of Islands, and the edge of the Shannon valley. If this eventually is proved to have been the case, the more obvious occurrence over the site of the Arthur Lakes would represent a subsequent phase. The area around Little Lake was certainly subjected either to a further phase or, more probably, a much later and more prolonged glaciation than the Arthur Lakes area. The evidence of these phases is very uncertain in this vicinity, and considerably more field work is necessary before a definite statement is possible.

The Lake River has eroded a tremendous gorge as it passes over the edge of the plateau. This has cut southward considerably in post-glacial times, and has removed much of the glaciated landscape just where the vital evidence of terminal moraines might have been expected. A depth of 200 feet has been eroded since the glaciation of the area immediately south of the Arthur Lakes. Incidentally, it may be pointed out that the Lake River has captured the drainage of the Arthur Lakes and Lake Leacock which originally flowed via the Lagoon of Islands and Blackman River to the Shannon. This capture appears to have occurred in post-glacial times, and is due to the considerably greater fall and, hence, cutting power of the Lake River as it passes over the edge of the tiers. There is also evidence of drainage from the south Arthur Lake to the Shannon in the vicinity of St. Patrick's Plains. This may be referable to an interglacial epoch prior to the formation of the lakes and the outlet via Lake Leacock.

7. The Great Lake Area.

This district lies to the west of the one previously described, and is separated from the Arthur Lakes plain by the Sandbanks Tier. It may be considered as a broad, flat valley which is mostly occupied by the Great Lake, 60 square miles in area, and, prior to the building of the Miena dam, averaging only 12 feet in depth, with very few places exceeding 20 feet (Legge, 1904). The plain is bounded on the east by the Sandbanks Tier, on the north by the

[*A. N. Lewis, Photo.*

V. Glacial Erratics on shore of Shannon Lagoon, below Miena Dam—*Great Lake.*

[*A. N. Lewis, Photo.*

VI. Basalt at "The Battery"—*Great Lake.*

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raised edge of the plateau, Sandbanks Tier joining to the high country south of Mount Tabletop and Mount Projection, these features themselves being portion of the Dry Bluff mass. To the north-west the elevated country is continued as Bastion Bluff, and to the west Split Rock Range runs southerly for some 10 miles. To the south-west the Great Lake plain merges into the Ouse plain, and to the south it is bounded by Barren Tier, which has been cut through by the Shannon River. The surface of the lake is 3333 feet above sea-level, and the surrounding ridges average 4000 feet. The physiographic features of the lake have been very fully described (Legge, 1902, 1903, 1904). The rocks represented are dolerite over the northern portion, Ross sandstone merging into felspathic sandstone over the central portion of the southern lake, basalt covering the plain drained by the Ouse south of Liaweene, and appearing at the Beehives and the Battery on the shores of the Great Lake, with dolerite again at the Shannon outlet.

On the edge of the tiers, at an elevation of 4000 feet alongside the Deloraine-Great Lake road, is Pine Lake, a typical mountain tarn, lying in flat terminal moraine country. Small ice-flows, moving southward, coalesced over the site of the lake during the last phase of the ice age. A little further north the Liffey, a tributary of the Meander, has cut an awe-inspiring gorge, as it flows over the edge of the plateau. This has removed much of the glaciated surface between Dry Bluff and Mount Projection by headward erosion. A major fault appears to traverse the length of the Liffey Gorge, and this probably runs southward via Half-Moon Marsh, across the site of the Great Lake and down the Shannon Valley, thence in the direction of the present pipe-line to the Ouse Valley, in the vicinity of Waddamana. However, the statement that this is one fault is at present only assumption. The overflow from Pine Lake, known as Breton Rivulet, crosses flat moraine-covered country for a mile or so, then drops over an eroded rudimentary cirque wall for 300 feet to Half-Moon Marsh. This latter is a typical glacial valley, and ice passed thence over the present floor of the Great Lake. Traces of glaciation descending in a south-easterly direction to join the lastmentioned flow are to be seen in Mickey's Marsh, half-way between Pine Lake and the Little Lake.

The Little Lake and the north-western section of the Great Lake are bounded by a series of small, and not very distinct, cirques. More distinct evidence of glaciation occurs

at the north-eastern corner of the Great Lake, and it appears that the main ice-flow passed south-westward from the high country south of Dry Bluff, and coalesced with the other flows mentioned in the vicinity of the centre of the northern half of the Great Lake. A distinct bar separates the northern from the southern portion of the Great Lake (Legge, 1904). At the period of maximum glaciation, ice probably covered this, and coalesced with flows from the Ouse valley and from Sandbanks Tier, to be described next. At a later stage this northern flow probably terminated as a stationary sheet just north of Reynolds' Neck while ice from Sandbanks Tier still existed, also as a stationary sheet, over the southern portion of the lake.

The southern shore of the Great Lake presents features worthy of special mention. In the first place, most of the dissected plain extending from the Pine and Ouse Rivers to Sandbanks Tier, south of the Split Rock, is covered by a sheet of olivine basalt, through which dolerite hills rise as islands, e.g., Murderer's Hill. The basalt country is very easily distinguished by its mild topography. A ridge of this rock extends as a peninsula for 3 miles into the waters of the lake, and terminates in the Beehives. After being submerged opposite the mouth of the Shannon it appears again towards Todd's Corner, at the Battery, and thence extends southwards over the shoulder of Barren Tier. The valley southward of this ridge is drowned by the waters of the lake, and is known as Swan Bay to the west and Todd's Corner to the east. The next ridge to the south forms the shore of the lake, and consists of a line of dolerite kopjes. Further southward again is another more or less parallel valley, occupied in its lower portion by the Shannon Lagoon. Then Barren Tier terminates the Great Lake plain by a third parallel ridge. The features mentioned are primarily due to erosion, as is shown by the fact that the basalt ridge at the Beehives appears at the Battery as a continuation of the dolerite ridge, with which it makes one physiographical feature in the latter locality.

The Shannon cuts through the dolerite ridge at the site of the Miena dam, the keystone of Tasmania's industrial activity. When the foundations for this structure were being excavated the dolerite was found to be seamed with wide bands of weathered rock, which isolated seemingly solid surface outcrops as large floating boulders. This was more marked on the banks than in the bed of the Shannon, which appears to have removed the weathered material. Dr.

[*A. N. Lewis, Photo.*

VII. Edge of Dolerite Sill. *Mt. Projection, Western Tiers,* from Deloraine-Great Lake road.

[*A. N. Lewis, Photo.*

VIII. Moraine at *Pine Lake,* north of Great Lake.

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Loftus Hills informed me after his inspection that the appearance was that of dolerite weathered *in situ*, and no suggestion that the bar was a glacial moraine could be found.

However, the valley south of the dam shows unmistakable evidence of glaciation. Erratics cover it sparsely from the Sandbanks Tier, across Todd's Corner, right to the Shannon Lagoon, and a few may be found on the west shore of the latter and in the valley leading to it from the south-west. At some stage ice passed down the Shannon, at least to the intake of the canal leading to the Shannon power-house, and probably further.

My explanation of the southern shore of the Great Lake is this. During the maximum extension of the ice age a large shallow ice-sheet covered the whole valley, and met the ice-sheet in the Arthur Lakes valley. Later, for a long period during the recession of this phase, smaller ice-sheets covered (1) the southern Great Lake to a depth of about 50 feet above the present water-level, deriving their source from Sandbanks Tier, the Ouse, and south of Murderer's Hill (this banked up against the northern slope of the dolerite ridge at approximately the present shore line of the lake); (2) immediately to the south a smaller ice-sheet, deriving its source from Sandbanks Tier and Barrier Tier, banking up against the latter. The Shannon gorge between the Lagoon and the Shannon power-house is, in its present configuration, definitely lower and wider than when the ice-sheets covered the area stated, although no evidence is at present forthcoming as to whether it is post-glacial entirely.

The dolerite bar and line of kopjes that now limit the southern shore of the Great Lake were eroded as a long razor-backed nunatak between these ice-sheets. It probably only protruded 50 feet at its eastern half from the ice, although the top of the ice over the Shannon Lagoon appears to have been some 50 feet lower than that over the Great Lake. It is possible that the Great Lake once drained to the Lagoon via Todd's Corner, and that the Shannon outlet at Miena was more recently eroded.

8. The Nineteen Lagoons - Ouse - Pine River Area.

The country between Mount Ironstone on the north-west, the Great Lake on the east, and the Pine River on the south-west, may be considered as the next geographical area, although no definite western boundary can be fixed. This is a bare, desolate moorland of rocky ridges, lagoons,

and swamps, difficult of access, and snow-covered during most of the year. To the north the edge of the Western Tiers rises in a long ridge (Bastian Bluff, 4400 feet, and Mount Ironstone, 4700 feet). Thence the land drops rapidly in talus-covered terraces to about 3700 feet, and then in a gently sloping plain for 20 miles, with a general south-easterly drainage to the gorges of the Ouse and Pine on the southern edge of the plateau. Near the middle of the plain a considerable nunatak ridge, the Little Split Rock, stands over Lake Augusta. South of this feature the valleys of the rivers mentioned and their many tributaries are more marked, and are separated by typically nunatak ridges of shattered dolerite, running generally south-east.

The whole of this area is intensely glaciated at least as far south as a line from Swan Bay to Lake Fergus, and I think, although the evidence is very slight, that ice at its maximum extension descended to the Skittleball Plains at least. At this period it probably coalesced with the ice of the Great Lake area across the plain between the Split Rock and Barren Tier. Much of the southern slopes of this area are covered by basalt, and consideration must be given to the different way in which this rock and the islands of dolerite protruding through it have been affected by weathering. It is easy, at first sight, to picture the topography of the basalt as due to ice, and that of the dolerite ridges as due to frost, action on the rock protruding through the ice-sheets, but the close association of rock type with topographical forms gives a warning that these differences may be due to normal weathering alone. For this reason, if it were not for the conclusive evidence of surrounding districts, I would hesitate to say that these basalt plains had been affected by ice. However, from the fact that ice did cover surrounding localities, and that basalt flows occurring on lower levels—for example, at Bashan—do not exhibit the appearance of an ice-cap topography, it is probable the plains between the Great Lake and the Skittleballs were covered by ice. Possibly the level, smoothed-out topography was due originally to pre-glacial erosion of the softer rock, and this induced an accumulation of ice during the ice age over the basalt, while the dolerite protruded as nunataks and ridges too steep for the snow to lie on. The ridge between Swan Bay and the Ouse, and that between the Ouse and the Little Pine Rivers, overlooking the Skittleballs, certainly show many small and rudimentary cirque features, and Lake Fergus is definitely of glacial origin. It is very probable that ice at some time

[*J. W. Beattie, Photo.*

IX. *The Great Lake*, looking north from Miena, over Swan Bay and Beehives, to Split Rock.

[*A. N. Lewis, Photo.*

X. Most southerly of the Nineteen Lagoons, showing morainal dam.

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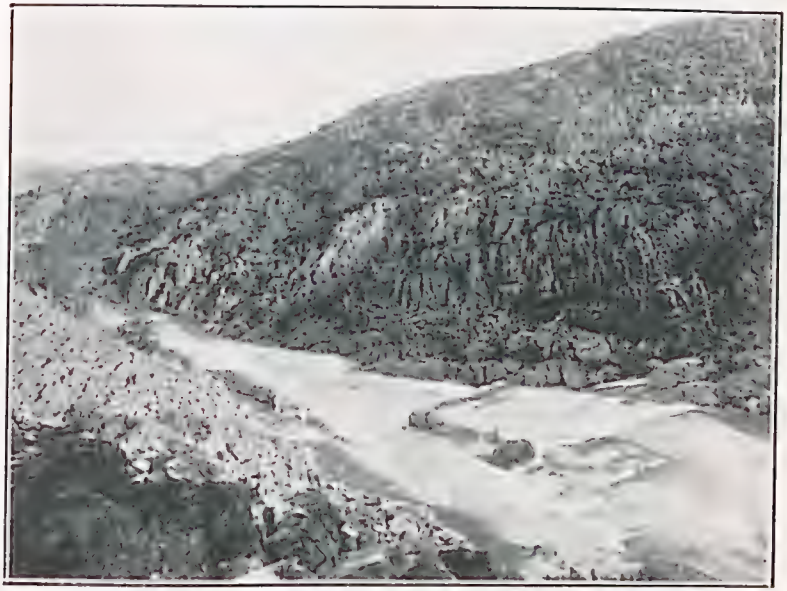

[*J. W. Beattie, Photo.*

XI. Gorge of *River Ouse* at Liaweene, showing extent of post-glacial erosion.

[*A. N. Lewis, Photo.*

XII. Gorge of *Shannon River* through Barren Tier.
Shannon power-house in foreground. Drop of pipe-line (290 ft.) shows depth to which Shannon has cut in under 5 miles.

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passed over the site of the Ouse bridge on the " Missing-link " track, and thence debouched on to the Skittleballs. Here, the post-glacial erosion appears to have been comparatively slight—not 50 feet in depth.

A little further north the effect of ice movement is more apparent. Here the sheet was divided for long distances by low parallel dolerite ridges, and some morainal deposits are apparent. A clear one exists in the valley of the Armytage Rivulet, due west of the Ouse bridge at Liaweene. Thence northward to the Nineteen Lagoon area the country is certainly, although indistinctly, a huge terminal moraine area, and Lake Augusta, with its surrounding lagoons and swamps, is the result of the indeterminate drainage typical of such topography.

This glaciation becomes more and more obvious as you proceed northward. On the flanks of Mount Ironstone are many mountain tarns, such as Lake Meander, Lake Ironstone, Lake Lucy Long, and others. These are impounded behind typical valley glacial moraines. Moreover, they represent a later phase distinct from and covering the morainal deposits of the Nineteen Lagoon country. Opportunity has not occurred for me to investigate in sufficient detail the evidences of superimposition of actual moraines, but Dr. Loftus Hills has informed me of the existence of strong evidence of a definite inter-glacial epoch between moraines in the vicinity of the head waters of the Fisher River, and this locality should be productive of most important results when time can be found to explore the moraines in the necessary detail.

9. Lake Echo Area.

Lake Echo presents one of those difficult contradictions which, nevertheless, afford the clue to the whole problem. It lies well south of what might otherwise be considered the glaciated area, and is entirely cut off from the Great Lake and Ouse valley glaciations by river-eroded valleys. Its height (2717 feet) is somewhat less than that of the lowest locality in which glaciated topography can be identified with certainty in the northern areas. Nevertheless its origin must be identical with that of the other large lakes of the plateau. In fact, its basin is glaciated, and the surrounding valleys have been eroded subsequently. It appears, therefore, to represent a residual portion of the plateau as it existed at the time of the maximum extension of the ice-sheet.

The lake is enclosed in a circle of hills, rising to about 3500 feet to the north-west and 3000 to the south. It is also a shallow sheet, 20 feet depth being exceptional. North of the lake are considerable plains which appear to be portion of the same feature, now drained by tributaries of the Ouse, the valley of which has cut into them. Ice moved southward across this plain, over a low saddle, and into the north-east corner of the lake. Smaller flows moved south-eastward from the high ridges known as The Tops, lying between the lake and the Nive valley. These coalesced over the present site of the lake. The lake is at present dammed by a dolerite bar, through which the Dee is cutting. To the north-east of this, and extending to the basalt flows at Bashan, is an outcrop of sandstone. Ice seems to have passed across the present mouth of the Dee, and the dolerite here is either shattered by nivation or lightly covered by moraine, probably the latter. The valley of the Dee near the lake is covered by luxuriant vegetation of typically western flora, and this effectually obscures the evidence of morainal deposits. Post-glacial erosion does not appear to have reached the lake-level.

In this vicinity, and between here and Lake St. Clair, there are numerous valleys that have the appearance of more or less drained lakes—for example, Victoria Valley and Bashan Plains. Mike Howe's Marsh, in the valley of the Blackman River, east of Lake Sorell, is another example of this feature, and the Lagoon of Islands and Lake Crescent afford examples of the connecting links between these marshes and the shallow lakes. I have not yet discovered, however, any trace of glacial action south or east of Lake Echo, or lower than 2700 feet west of the Nive River, and these features are probably due to recent earth movements, with or without the interposition of the effects of ice.

10. The Ninety-Nine Lagoons Area.

Westward of the Pine River catchment, and stretching thence to the dissected western edge of the plateau, is a district well named the Ninety-nine Lagoons, although probably ten times that number of lakelets exist. Here the acreage covered by water may exceed that which is dry. The head waters of the Mersey and Forth, and their many tributaries flowing north, have cut deeply into the original plateau surface, and the Nive and Clarence, flowing south, have also eroded considerable areas, although not nearly

[J. W. Beattie, Photo.

XIII. Gorge of *Ouse* at Waddamana.

Power-station is on bed of river, 1200 feet below spot where pipes disappear. Uneroded plateau covered by basalt lava flows, and either glaciated or slightly affected by near proximity of glacial conditions, in background.

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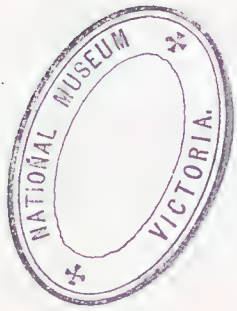
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[*A. N. Lewis, Photo.*

XIV. *Lake Echo*, looking south.

[*A. N. Lewis, Photo.*

XV. Glaciated Valley immediately north of Lake Echo.

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to the extent of the northern rivers. The district is very flat, and to the north entirely covered by terminal moraine deposits, amongst which the lakelets lie. To the south the country is similar, but is traversed by long, low, parallel nunatakal ridges of shattered dolerite. A few outstanding mountains protrude, such as Culmar Bluff and the China Wall. These show typical nunatak features. I have not investigated this area in detail, but it appears that the ice responsible for the topography moved south-eastward from névé fields in the Barn Bluff, Pelion, and Du Cane Ranges, and is referable to the last phase of the ice age.

The Mersey, Forth, Nive, and Clarence have eroded much of the glaciated country, and the present features of these valleys are certainly post-glacial. They have not, however, entirely removed the glaciated plateau at their head. Both the Forth and the Mersey are working down fault-lines or zones. There appears to be a distinct break in the geology of the plateau from a general line through the Forth valley, and continued southward. Mr. McIntosh Reid's mapping indicates that westward of this line the elevation has been more considerable and, it seems to me, from the amount of erosion, earlier. Sedimentary rocks, pre-Cambrian schists, Permo-Carboniferous series, and Ross sandstones, &c., are to be found at 4000 feet, and are far more common than is the case further east. The dolerite appears as an elevated and thoroughly dissected sill.

11. The Western Ranges.

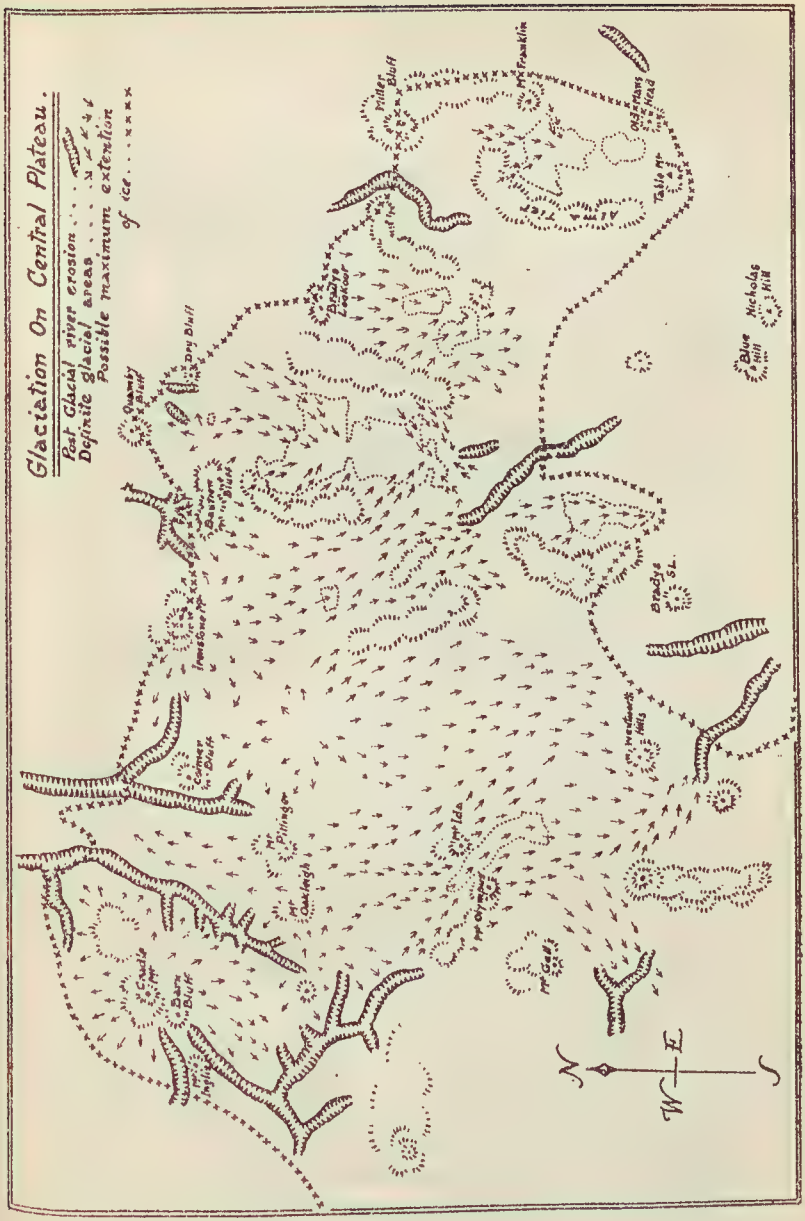
These have been fully described, as before mentioned, and I have no further data regarding this portion of the plateau. I merely desire to point out that these ranges must be considered as part of the Central Plateau. Their physiography has been determined by similar influences, although here these influences have been more intense. The main valley features and the dissection of the plateau were largely completed in pre-glacial times. Thus the ice was accorded fields on which to accumulate and valleys through which typical valley glaciers could move. These features, and their absence further east, are sufficient to account for the difference in the glacial forms now apparent. Also, the precipitation was considerably greater on the west of the plateau, and thus the ice was enabled to reach lower levels. Ice certainly descended to 2300 feet at Lake St. Clair, and perhaps it reached as low as 2000 feet. The country in

the vicinity of the Clarence Lagoons, and that crossed by the West Coast-road in the Clarence Valley and westward to the Derwent, shows evidence of glaciation during an early phase. The Derwent has eroded its valley to within 10 miles of Lake St. Clair very considerably since glacial times, and many possible traces of the lower limits of ice movements have been removed.

12. Pleistocene Glaciation on the Central Plateau.

To summarise the conclusions forced by the field evidence noted above, it is sufficient to say that the plateau surface, as existing in Pleistocene times, was subject to intense glaciation in its north-western quarter, and thence the ice-sheet became thinner and finally broken into small occurrences. The whole plateau above 2800 feet was within the permanent snow-line during the most intense epoch. Except towards the west, the ice took the form of a fairly stationary ice-sheet, and the typical features of valley glaciation could only develop in a few localities. In consequence of the flat topography and the hard dolerite, little erosion was effected, and, from the same cause, morainal deposits are few. The erosion forms are mostly those of a typical ice-sheet. Post-glacial erosion in the river valleys has removed the traces of valley glaciation if such ever occurred. On the higher levels the ice-cap eroded considerable and frequent hollows by nivation when stationary during the recession period. There is distinct evidence of two phases and indications of a third and more extensive phase. The last phase appears to be superimposed on the earlier one, and the terrain presents great possibilities for the further study of this vital problem when the opportunity presents itself.

It must be borne in mind that the present-day conditions over the plateau are severe. During the winter of 1920-21, when the Great Lake construction works were in full swing, football matches were played on the ice of the lake. The winter snowfalls of the present time are sufficient to account for the treelessness of the higher plains, and ice in modern times has piled up shingle terraces round the lakes (Legge, 1902). Conditions similar to these must have existed at considerably lower elevations during the ice age. This and the ice-cap conditions during the maximum phase of the ice age, and the extent of post-glacial erosion, make it very difficult to say with certainty what was the limit of the ice-cap of the plateau. I have no hesitation, how-



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ever, in saying that the country north of a line from Mount Charles to Table Mountain was affected, during the Pleistocene, if not by permanent ice, certainly by heavy winter snowfalls.

The ice-cap was never very thick; perhaps 100 feet was its maximum in the eastern half of the plateau. It covered pre-glacial plains, and all the then existing hills and prominences protruded as nunataks of bare rock. Most of this rock was dolerite, which is seamed with cooling cracks. The intense frost action, and the effect of heating during the day and freezing during the night, shattered this exposed rock, and gave us the typical hill features of this area, namely, a general appearance of vast accumulations of loose boulders.

The remarkably clear glacial topography made easily accessible by the West Coast-road clearly shows that, during the maximum phase of the Pleistocene ice age, the whole of the country from the Great Lake to the sea was covered by ice, except where mountains protruded. Evidence at present to hand points to a coalescence of a multitude of mountain glaciers into a more or less stationary ice-mass completely filling the valley and plain areas. The apparent gaps in this sheet in many places, as in the lower valleys of the King and Gordon and Derwent Rivers, are due to post-glacial erosion. This has effected a modification of the physiography of Western Tasmania to an extent not hitherto appreciated, and points to considerable uplift and rejuvenation by the river systems between the maximum phase and the most recent mountain tarn phase of the ice epoch which has been responsible for the more apparent moraines.

13. Post-Glacial River Erosion.

The degree to which the rivers draining the plateau have cut into the glaciated surface of the original uplift has surprised me. This has not occurred materially in regard to the most recent morainal deposits, but the evidences of the earlier, and most extensive, glaciation have been largely removed. This forces the inquiry, whether the glaciated area of many of our other plateaux has not been greatly underestimated, and whether we have not been missing the identification of the lower limits of the Pleistocene ice-sheets by reason of subsequent erosion. This, in its turn, emphasises the importance of fuller investigation of glaciation at lower levels as occurring on the West Coast.

Commencing with the Ouse Valley, we see, at Waddamana, a gorge 1200 feet deep cut in the original plateau surface, which has also been thoroughly dissected by small tributary valleys of the Ouse. The remnant of the plateau above these valleys shows evidence of having been affected either by an ice-sheet or by severe snow conditions approaching those of permanent ice. Such topography crosses the Shannon and Lake Echo depressions, and the Ouse has eroded either its whole gorge, or substantially so, since the period of the maximum extension of the ice. This river has, by headward erosion, cut right into the moraine-covered plateau surface as far north as Lake Augusta. Opposite Swan Bay it has cut about 200 feet into the plateau since the maximum phase of the glaciation, and this is true for some 5 miles northward to the gorge north of the Ouse Canal at Liaweene.

The latter phases of the glaciation occupied this valley to about a mile north of Liaweene and further south in the Pine River and tributaries of the Ouse. The Ouse itself has cut about 50 feet into its valley as shaped by this last phase, but, owing to control by dolerite bars, much of the glacial topography in the upper portion remains.

The Shannon from the power-house to the Lagoon shows a smaller, but similar, gorge cut, or very considerably deepened, since the ice receded from the Greak Lake. This has cut at least 200 feet in dolerite in post-glacial times. The Dee and Nive have also cut considerable, although lesser, gorges in the glaciated surface of the plateau. It is apparent that the ice has considerably interfered with the normal sequence of river erosion. I cannot at present throw any light on the pre-glacial drainage. It is possible that, at some stage, the Great Lake drained into the Ouse, and thence, via the Skittleballs, into the Nive; but this is uncertain. The Shannon to a lesser extent, and the Ouse to a greater extent, have been active, in recent times, in capturing drainage from surrounding streams. The gorges of these rivers are of very recent extension into the plateau, and the Ouse has certainly captured much of the drainage of the Nive, and may shortly behead the Little Pine River, &c., at the Skittleballs.

A factor that is apparent in the upper portion of the Ouse, and which I have observed elsewhere, is that a stream will frequently erode round the side of an ice-filled valley, and a large glacier in the main valley will protect the

[*Spurling, Photo.*

XVI. Edge of Dolerite Sill—Valley of Fisher River.
Showing glaciated plateau above and post-glacial erosion of Mersey drainage system.

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[*J. C. Breadon, Photo.*

XVII. *Lakes Sandy Beach and McKenzie,* under Mount Ironstone. Note moraine in foreground, and also separating lakes.

[*Spurling, Photo.*

XVIII. *Mount Ironstone* and glacial lakes in vicinity.

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terrain from erosion when a stream in a smaller adjacent valley is wearing down a bed below that of the ice-filled principal valley. After the disappearance of the ice these streams capture the drainage of the main valleys. It is, therefore, frequently found that the main drainage course of to-day was not the main valley in pre-glacial times nor the site of the largest glacier.

The northward flowing rivers, Forth, Mersey, Meander, Liffey, and Lake, have cut far deeper and more spectacular gorges, having reached soft sedimentary rocks below the dolerite (as is also the case with the Ouse). Their shorter and steeper slopes have enabled them to do this. But, at the same time, as they are cutting into the highest portion of the plateau, they have interfered less with the glaciated surface. In spite of this, river erosion has proceeded in all these cases to a very considerable extent since glacial times, perhaps to the depth of 2000 feet since the time of the maximum extension of the ice. All these questions of erosion are very uncertain, as evidences of valley glaciers in the gorges mentioned have been entirely removed.

14. Older Peneplain of the Derwent Valley.

Mr. Clemes has drawn attention to the existence of a lower plateau extending from Lake St. Clair to Lake Echo at an elevation of some 2500 feet (Clemes, 1924). This is so, but it extends far beyond the eastern boundary assigned by Mr. Clemes, and may be regarded as the same feature as the Oatlands spur of the plateau described by Mr. Nye (Nye, 1921). From Hamilton northward to the Steppes, north-westward to Lake St. Clair, north-eastward and eastward to Oatlands, Tunnack, and Colebrook, there is evidence of a dissected peneplain. This exists now as mere flat-topped residuals between wide valleys, and appears to have been uplifted in a series of step-faults to the upper levels of the Central Plateau. It corresponds with the Midlands in general, but is much more deeply cut by the river valleys. The general trend lines of the main uplift on the southern boundary of the plateau are not as clear as on the other sides, and the possibility of a partial subsidence, although not to the original level, must not be ignored. In fact, the uplift of the Central Plateau appears to have occurred by segments at different stages and to different heights, thus further complicating the deciphering of the physiographical influences.

15. Origin of the Great Lake and Other Lakes on the Central Plateau.

As has been sufficiently indicated, the origin of all the lakes, except the Great Lake, Lake Echo, Arthur Lakes, Lake Sorell, and Lake Crescent, is definitely due to glacial action, and they in nowise differ from the mountain lakes and tarns of the western ranges. The only doubt exists as to the large lakes above named. It is certainly a difficult problem, and the evidence is not very obvious. The theory that they are due to original hollows in the dolerite must be discarded in view of the time that has elapsed since this rock first appeared, and the theory that they are due to inequal erosion of overlying sandstone is not sufficient to account for all the physiographic features surrounding these lakes. If there were no possibility of ice action, of course, another explanation would have to be sought, and previous opinions proceeded on this assumption. I have presented, I hope, enough evidence to show that the whole area was subject to ice action to a greater or less extent, and therefore the obvious cause was actually in operation.

The lake basins in question have certain features in common. All except Lake Echo appear as two sheets, connected to a greater or less extent. In every case sandstone and basalt occur towards the overflow side, while the upper sides are shallow cirque-like depressions in the dolerite. These factors are common elsewhere, and therefore may be mere coincidents. The lakes are all extremely shallow for their area. This must be largely due to post-glacial deposition, particularly of diatomaceous mud, but the original flatness of the plains in which they lie is obvious. More important is the factor that in every case there occurs a considerable hill or tier on the outlet side, and the lakes lie over the site of the coalescence of two or more ice-flows, of which one or more moved to some extent against the general direction of the movement of the major flows. None of these lakes is dammed by a moraine, although morainal deposits occur to some degree near the outlet of all except Lakes Sorell and Crescent. It is clear, from evidence in the Midlands, that, although a river cannot erode a lake basin in the normal course of erosion, where a small creek suffering from floods cuts from a sandstone area through a bar of dolerite, it sometimes erodes the sandstone behind the bar to form a swamp which will flood into a lake. Add an invasion of ice to such an area, and the swamp could be

[*Spurling, Photo.*

XIX. Ouse-Mersey Watershed.
Lake in foreground drains north, lake in background drains south.
Note ice-cap topography.

[*Spurling, Photo.*

XX. Glacial Topography at head of Nive River, in the Ninety-nine Lagoon Country.

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deepened sufficiently to form a basin such as is now occupied by the large lakes of the plateau. It is not absolutely clear, however, that such a simple explanation, which is a possibility, is actually the whole story of the development of these lakes.

In my opinion, these large lakes occupy hollows which represent the final sites of small ice-sheets, the last remnants of larger sheets which imparted the typical ice-cap topography to the plains in which the lakes lie. During the recession period the ice became confined to certain localities, and here eroded slight depressions by nivation.

At the same time, the whole of Tasmania is rising at the present time, and this has continued since Pleistocene times, allowing for the more rapid rise of the sea-level during a comparatively short space of time. The valleys of all the streams show slight recent uplift, and this is particularly plain in the valleys of the Dee and Nive. It is quite possible that this gentle uplift has been sufficient to cause an interruption to the drainage in the flat glacial plains, and I think that this influence has been partly responsible for the present existence of these lakes. I do not think that we would have had the lakes if it had not been for the effects of Pleistocene glaciation on the plateau topography, but the proximate cause appears to have been the slight earth movements operating on the ice-sheet topography.

16. Geology of the Hydro-Electric Scheme.

Sufficient description has been given of the terrain of these works, and it is only necessary to summarise the conclusions that all the evidence points to. The foundation of the physiographical influences which have made the scheme possible is the uplift of the plateau in sufficiently recent times to permit the bounding escarpments to persist. This has rendered possible the existence of high-level lakes, and has given the rivers flowing over the edge of the plateau the power to erode deep gorges in close proximity to the storage sites on the higher levels.

The fact of the existence of the Great Lake itself means little to the scheme, but the fact of the wide, flat plain in which it lies is vital as a site for sufficient storage. This, as has been shown, is due, primarily, to erosion by a slowly moving ice-sheet. The slight degree of erosion by this sheet has resulted in the absence of deep morainal deposits which would have gravely militated against the construction of a

suitable dam. Thus, glacial action has been the primary factor in making the whole scheme possible.

The next consideration is the fact that the Shannon River has cut through Barren Tier, that the Ouse has also done so, but on a separate and parallel course, and that in so doing the Ouse has eroded its bed to a depth of some 1200 feet below that of the Shannon, and has done so at a spot where the divide between the two rivers does not rise appreciably above the level of the bed of the Shannon.

These factors are due principally to the headward erosion of the rivers mentioned, made possible by the fall imparted by the original uplift. Both rivers have probably found a major fault line or zone. The Shannon at the Shannon power-house flows out on to the original surface of the plateau in this vicinity, and has worked back thence to the Lagoon. The drop is 300 feet in 5 miles. This portion of its course has been eroded into a considerable gorge.

Many factors have contributed together to enable the Ouse to deepen its valley to such an extent below that of the Shannon. Opposite Swan Bay the Ouse is scarcely 100 feet below the level of the Great Lake. Ten miles down its course it is 1200 feet or so below the level of the Shannon. Twenty years ago Mr. Clemes suggested to me that this was due to the fact that the Shannon drained out of a lake, and consequently left it without sediment, and the Ouse, passing round the side of the lake, was able to commence with a considerable sediment load by the time it was opposite the source of the Shannon. My observations confirm this. The Ouse, at the Skittleballs bridge, is moving a considerable shingle load, and undoubtedly this is an important factor. But it is not the only one. The Ouse had, originally, a far greater flow of water, and, from its more westerly situation, its numerous tributaries, its barren catchment area, and the absence of considerable lake barriers in its course, is subjected to violent flooding from which the Shannon was free. More than this, the Ouse has a shorter, and more direct, course from the plateau to its lower junction with the Shannon, and, most important of all, has reached the soft Permo-Carboniferous rocks below the dolerite at a higher elevation than has the Shannon.

Permo-Carboniferous rocks appear in the valley of the Ouse at Waddamana at an elevation of some 400 feet above the present bed of the river, which has considerably deepened its valley in these rocks, while the Shannon is still eroding through the hard dolerite for a much longer distance. The

[*Spurling, Photo.*

XXI. *Rugged Mountain* from Valley of Mersey.

This is a typical nunatak under present Tasmanian conditions, viz., bare rock above, swampy glacial valley below, dense vegetation on talus-covered slope. Rugged Mountain is the most easterly of the residual mountains of the western edge of the plateau.

[*C. E. Lord, Photo.*

XXII. *The Central Plateau,* looking east from Mount Olympus.

Lake St. Clair in the foreground, with Mount Ida beyond. Traveller Rest Lakes in right background, and Mount Ironstone on skyline to left.

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Ouse found a fault-line in its lower course, and this has enabled it to penetrate the dolerite more easily. The greater angle of slope, its greater volume, and sediment load has enabled it to cut deeper into the plateau wall, and this, in turn, has given it greater power in ascending ratio. To these factors the depth of the Ouse gorge at Waddamana below the Shannon valley is due, and thus the other vital factor of the sufficient fall is present. The pipe-lines from the Shannon diversion follow the original surface of the plateau as it appeared in Pleistocene times. At no great distance in the future the Ouse would have beheaded the Shannon in the vicinity of the transmission-line to Launceston, if it had not previously drained the Great Lake just north of Murderer's Hill, in which vicinity a tributary of the Ouse approaches within half a mile of the shore of the lake at a lower elevation.

17. Acknowledgment.

I acknowledge with gratitude the assistance of Mr. Eric Brock, of Lawrenny, who kindly drove me to the Lake Echo, at the source of the Dee, and thus enabled me to complete this paper; the services of my friend, Mr. F. C. Mitchell, in the field, and in assisting me with the plans accompanying this paper; of Mr. Spurling, for the photographs of the western portions of the area, taken on a trip he made from Mount Ironstone to Lake St. Clair; and of Mr. C. E. Lord and Mr. J. C. Breaden, for other photographs reproduced in the paper.

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VOYAGE OF THE "MARY AND SALLY" TO MACQUARIE ISLAND FOR THE PURPOSE OF OBTAINING SEA ELEPHANT OIL AND SEAL SKINS.

(November 16, 1813—March 13, 1814.)

By

W. L. Crowther, D.S.O., M.B., V.D.

Plate XXI.

(Read 10th October, 1932.)

This vessel of 130 tons, Captain James Kelly, master, is noted in the "Sydney Gazette" of 18.9.32 as having left Sydney Cove for the Derwent, en route for Macquarie Island. After a stay of nearly two months at Hobart Town her voyage proper commenced on 16th November, 1813.

The brig was no stranger to the Southern Antarctic Islands, and, since her arrival from Bengal, had made voyages in the two previous years to Campbell and Macquarie Islands, under the command of Captain Feen.

At this time, two and a half years after its discovery, although the fur-bearing seal had been so depleted in numbers, Macquarie Island was still the home of large numbers of sea elephants.

The object of the voyage was primarily to obtain oil from the latter and the skins of the fur-bearing seal.

The narrative that follows is taken from a manuscript journal in the handwriting of Captain James Kelly. This came into the possession of the writer some five years ago from the widow of the late Joseph Kelly, a younger son of the captain.

Written on old hand-made paper, with ink that has kept its freshness, and bound in kangaroo-skin leather, this log is of the greatest interest.

Robert McNab, the great historian, knew of no logs bearing on sealing at Macquarie Island; and by this log, taken in conjunction with the account of the Bellinghausen Russian Expedition (1) we are able to visualise the daily routine, with the hardship and peril of the sealing gangs and the little ships that ministered to them.

On 16th November, 1813, the master of the brig writes:

> "At 6 p.m. fresh breezes and cloudy, the extremes of the land West by South to North East. Tasman's Head bore N.N. East, distance 4 leagues. From which I take my departure for Macquarie Island . . . . I allow 12 miles set Easterly . . . ."

The last sentence is most significant. The island lies some 850 miles south and a little east of Tasmania, and the prevailing winds are westerly. Captain Kelly at that date had no instrument (chronometer) by which he could estimate his longitude; that is, his distance east or west of Greenwich.

He could estimate, however, by the sextant and by "dead reckoning" the distance south that he had travelled; that is, his latitude.

It was, therefore, of great importance to him to know what "set" he was making to the eastward, as then when he had made his proper latitude all that would be required would be for him to steer either east or west, according to his estimated position, until he made his land fall.

Sailing steadily, with light winds and cloudy weather, he notes, five days later: "I allow 9 miles set to Easterly this 24 hours."

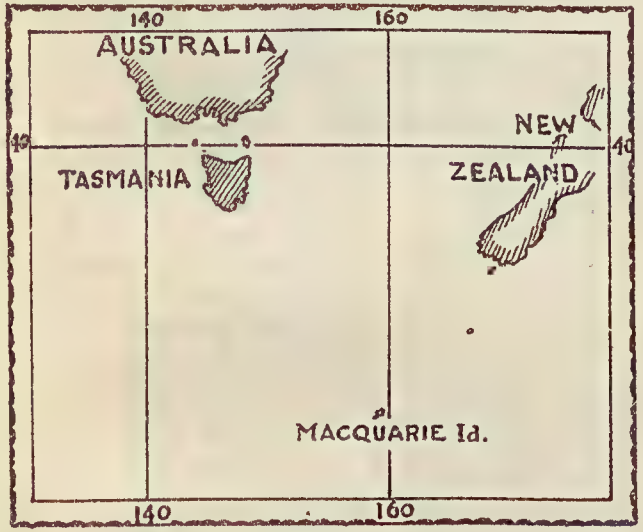
The days passed without much incident, and on the 24th the small boat is given a coat of damm, a black shag is seen, and the weather becomes worse.

Strong gales, with heavy snow and sleet, are noted on succeeding days, until 29th November, when he wore ship to the S.W., and bore up for the island. Heavy weather and poor conditions prevented land being sighted until next day, when at noon the land was seen bearing east distance 3 leagues, at a latitude of 54° 20′ south.

On 1st December, at half-past seven, the "Mary and Sally" came to with the best bower (anchor) in 13 fathoms. Her anchorage was reached by sailing past the north end and down the east coast of the island until sheltered by the land from the westerly wind. On sending a boat on shore "to look at the place, found enough Elephant to begin oiling"; and so "at daylight began to land hoops and provisions and empty casks."

On the same day nine men, with two officers, were appointed to land and procure skins and oil.

MACQUARIE ISLAND
Inset Map
shows position
in relation to
Tasmania.


140
160
AUSTRALIA
NEW
ZEALAND
TASMANIA
MACQUARIE Id.
140
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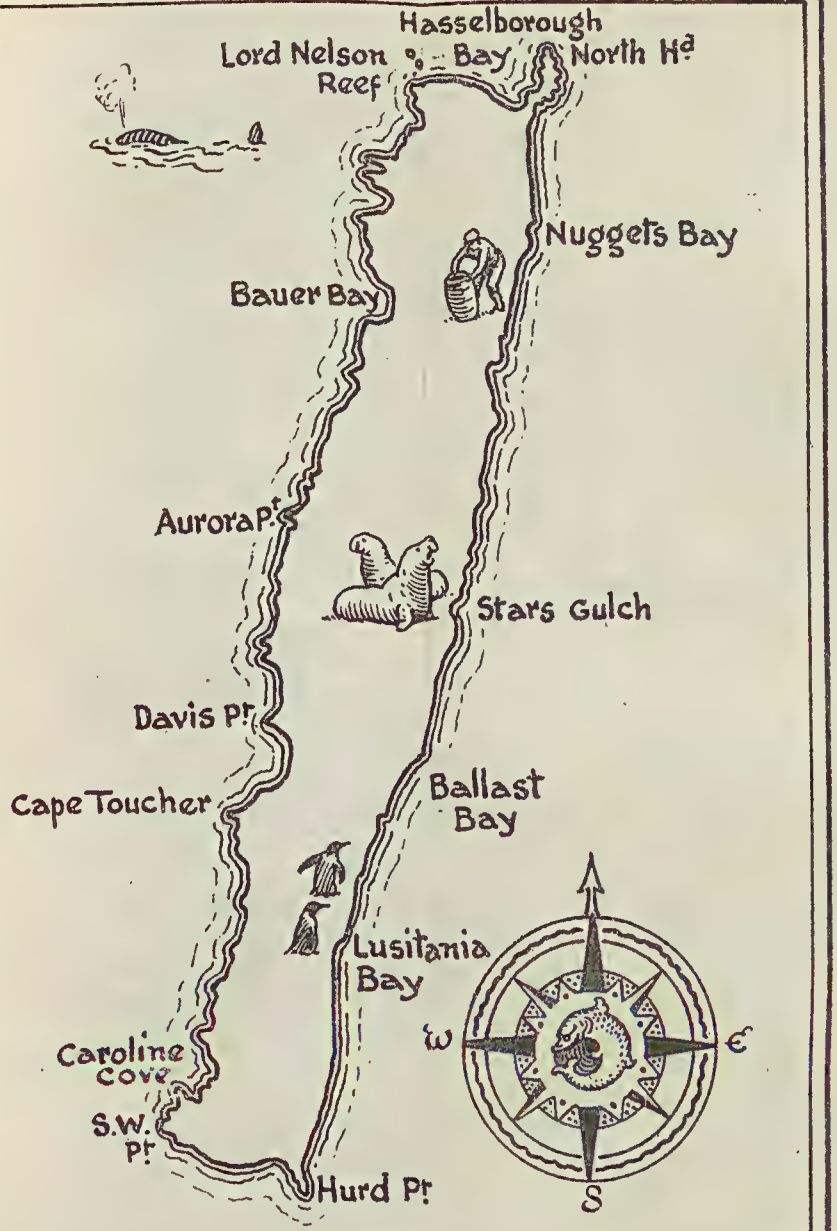
Hasselborough Bay
Lord Nelson Reef
North Hd
Nuggets Bay
Bauer Bay
Aurora Pt
Stars Gulch
Davis Pt
Cape Toucher
Ballast Bay
Lusitania Bay
Caroline Cove
S.W. Pt
Hurd Pt
W
E
S
DCP.

On the following day "what other stores were wanted were landed and in particular cooper's gear and stooks and hoops."

The landing party reported that they had not seen one seal (fur). Preparations were also made for landing the salt.

Here it may be said that salt was indispensable for curing the skins of the fur-bearing seal, and was mostly procured from Kangaroo Island.

It is probable that, before putting into the Derwent from Sydney, the brig may have gone to Kangaroo Island to obtain a supply.

On the ship preparations were made for rafting off the oil, and slings were made from a pair of foretopgallant stays for the same.

On shore the party was killing and procuring oil, and on the 5th ten casks, containing 630 gallons, were brought off by the boat and stowed away.

As well as killing in the neighbourhood of the works, sea elephants were being taken in Hasselborough Bay, on the western side of the north end of the island. Their blubber was rafted round by the ship's boat, which had previously landed empty casks and salt from the ship.

By the 16th of the month 70 casks of oil were stowed on board, and next day the weather changed to south-easterly, and the "Mary and Sally" had to slip her cable and run for it. The log for the day reads:

> "First and middle parts light airs at N.W. Employed clearing the decks. At 4 a.m. set in fresh breezes at E. with rain. Hoisted the boat in and got a spring and slip rope on to the cable ready to run as soon as the wind should veer a little either ways, not being able to clear the land on either tacks. At 10 the wind came to S.E. by East, got all sail set, at half-past 10 cut the cable and cleared the North Head. At noon fresh gales and hazey weather, standing to the S.W. The North Head bore N.E. by E. the distance 7 miles."

After four days, the weather improving, the brig returned to her anchorage, using the small bower with 12 fathoms, but was unable to pick up the anchor she had slipped. Again the weather changed, and

> "At half past 3 (a.m.) hard gales and heavy sea from the N.E. caused us to cut from our anchor and run around the South End of the Island."

Another week was passed, with hazy weather, hard gales, and continued seas, until on the 29th December the wind came to S.W., and the brig hauled round the north bluff to her anchorage.

"Hove short and got the best bower on board, hove up the small bower and secured it"—so the log reads, and it was no mean feat of seamanship either, to have secured both the anchors she had had to abandon previously.

The log makes no mention of Christmas Day for 25th December, and merely remarks on 31st December that another 34 casks of oil were got on board.

The new year (1814) commenced with weather still westerly, with the people employed on board as necessary, and on shore assisting the works. On the next day, however, came a change, and the log speaks for itself:

> "Began with moderate breezes at N.W. and hazey weather at midnight wind N.N.E. Hoisted the boat in and got a slip rope and got a buoy on the cable, at 2 a.m. wind N.E. by E. Slipped the cable and ran to the S.E. At 3 strong gales, close reefed the topsails, at 5 hard gales at East, reefed the foresail. Carrying a heavy press of sail to clear the Island. With heavy rain at 6 saw the South End bearing N.W. distance 4 miles, took in all sail and ran under poles. Still blowing very hard at East, at 10 more moderate. Course W. by S. at Noon wind S.S.E. and cross sea, hove too head S.W., Latitude 54 · 54."

The next day, at 2 p.m., the wind chopped to the S.W., and blew with increasing force, and at midnight a heavy sea was shipped, but did no damage. The brig bore up for the anchorage, and "at noon got the end of the cable onboard and all things clear for receiving oil."

The anchorage from which the ship was forced to run at 2 a.m. of the previous day was the North-Eastern Bay of later navigators. Ainsworth ([2]) describes a gale there on 5th February, 1912, as follows:

> "A tremendous sea worked up, and the ocean for the distance of a mile from the shore was simply a seething boil of foam. Hugh waves dashed onshore running yards beyond the usual marks and threatening to sweep across the Isthmus. The top of the waves could be seen flying over Anchor rock, seventy feet high and spray was blown right across the Isthmus."

One can picture the little brig, in the darkness and under such conditions, trying to work her way to windward, so as to clear the southern end of the island.

The responsibility of her master, who had to keep a sufficiency of sail and yet not lose her spars, and his relief when a safe offing had been effected, and he could order sail to be taken in and the ship allowed to run under bare poles.

A week of quiet followed, work going on all the while on shore, and on 10th January 10 hogsheads of salt were started into the captain's cabin ready to put oil into the casks.

The next day Captain Kelly came to a decision to try the west, or weather, side of the island, and, slipping his cable, ran round the northern end. With moderate breezes at S.S.E. he closed in to the land. His dual purpose was to obtain firewood from the wreck and look for fur seals.

This wreck, the first to occur on Macquarie Island, was of the " Campbell Macquarie," 248 tons, which, on 10th June, 1812, ran aground, and afterwards went to pieces. Her crew of 12 Europeans and 30 Lascars were all got ashore. She had nearly three suits of sails, and when the weather cleared up the crew succeeded in getting them on shore, where they were stored in a hut, which was afterwards accidentally destroyed by fire. All her stores were lost, independently of which she had taken on board 2000 prime skins, 36 tons of salt, and 118 tons of coal in lieu of ballast.

While on the island four of the Lascars died, also a seaman of the " Mary and Sally " (then lying there) named Thomas McGowen ([3]).

The ship's boat returned with the wood from the wreck, and at four went back to the cove, where 59 seal skins were procured. A further 296 skins were taken in the next 24 hours, when the brig returned by the northern route to the anchorage. At North-Eastern Bay the boat, having been stove, was sent on shore for repairs, and the skins salted.

No less than 69 casks of oil were taken on board in the three succeeding days, and the log for 18th January records:

> " Cleaning out the fore peak and stowing oil. Latter part employed getting the things onboard ready to move to Ballast Bay as the Elephants is all killed at the N. end of the Island.

> "All hands and boats employed in moving the pots and houses to the new location and the empty casks were also rafted along the coast. We find at Ballast Bay all the salt casks belonging to Geo. Howe, all moved from the place where they was left, appear to be washed away by the surf some a mile distant from each other and several stove with the rocks."

So reads the log of the 21st of January. Two days later the "Mary and Sally" weighed, and brought to in the bay, about half a mile from the shore, with the best bower in 15 fathoms.

After four days' westerly weather came signs of a change, until at 5.30 p.m. of 28th January a change of wind forced the brig to slip her cable and run. On the same day "the people" were put on a reduced ration of 1 lb. of bread (i.e., biscuit) per week.

This easterly weather continued for ten days, varying from strong to moderate winds, and in one squall the square mainsail was split all to pieces, as Kelly puts it, "the sail being very old and unrepairable." As a substitute the next day the foresail was bent for a mainsail. Some difficulty was experienced on 10th February in light, baffling winds, in regaining the anchorage in Ballast Bay. At daylight the next day some of the shore party came off to assist getting the anchor. The log records: "Ran a hawser to the cable, hove up the small bower and hauled the vessel to our anchor we left on the 28th of last month."

During this fortnight of easterly gales, whilst the brig was at sea, her shore party reported that, owing to bad weather, they had got but little oil and a small lot of 30 seal skins.

Preparations for leaving the island now commenced. Oil was rafted off, and in a blow from the north-west three casks, two hogsheads, and one 100-gallon cask were blown away and lost.

> "Two boats gone to the North Head to bring a part of the old staves onboard and shooks. All the bad and broken staves we were obliged to burn for fire as our fire wood was all used for stowing the casks."

So runs the entry for 10th February.

The following four days were full of activity; 73 more casks of oil and four casks of fresh water were taken on

board, with a loss of one cask of oil and two of water on rafting from the beach.

The cooper was employed shaking out the empty casks to stow away.

All stores were off and stowed below, and the log for Saturday, 19th, read:

> "Began with light airs and variable, employed getting all the things off from the shore and stowing same away, hoisted the boats in and stowed them and hove short, at half past seven p.m. light breezes at North, weighed and made sail, got the anchor on the gunnels, bound for the River Derwent.
>
> "At midnight North End of the Island bore West 5 miles from which I take my departure."

The little brig, heavily laden, made her way slowly to the northward towards home.

Strong gales were experienced, and on the second day's run, at half-past 3, a heavy sea was shipped, which stove the boat over the stern. No other damage was received, however.

Her progress was slow, and it was not until 8th March (18 days from leaving Macquarie Island) that Van Diemen's Land was sighted. On that day, at 3 p.m.: "Saw Oyster Ild. W. by N. 7-8 leagues. The brig was shipping and making a lot of water in the hard gale."

During the next two days Oyster Island was still abeam, but on 9th March, at sunset, Cape Pillar was S. by W., 10 miles, and at daylight the next day, with a course S. by E., Oyster Island bore W. by S., distance 8 miles.

Two days later the log ends with the "Mary and Sally" "running for Cape Pillar, at 4 Cape Pillar bore N. by E. distance 1 mile. Increasing breeze, clear weather."

McNab (4) reports her return to Sydney on 20th January, 1813, with a cargo of 80 tons of elephant oil, got in three months at Macquarie Island.

It is reasonable to assume that most of the intervening time was spent at Hobart Town, where no port records for so early a time remain in existence.

Of the subsequent history of this stout little brig I have no record, but Captain James Kelly from about this date must have commenced his long association with Hobart

Town and Van Diemen's Land. An association which was to bring him fame and honour as a pioneer explorer and discoverer of Port Davey and Macquarie Island, and to afford him place and power as a harbourmaster and owner of a fleet of whaling vessels, and, in his latter days, such reversal of fortune as to cause him to petition the Governor of the day for a position as wharfinger to the splendid port of Hobart Town, to the development of which he had done so much.

REFERENCES.

(1) MURIHIKU, Robert McNab, p. 190 *et seq.*

(2) MAWSON, "The Home of the Blizzard," II., p. 183.

(3) MURIHIKU, Robert McNab, p. 128.

(4) *Ibid.*, p. 269.

The nomenclature of the map of Macquarie Island is taken from "The Home of the Blizzard," by Sir Douglas Mawson. The map itself is the able work of Capt. D. C. Pearse, M.C.

LETTERS OF JOHN MARTIN, THE IRISH POLITICAL PRISONER.

By

Mrs. J. A. McElroy.

(Communicated by Dr. W. L. Crowther.)

(Read 10th October, 1932.)

Some months ago there was handed to me from St. George's Rectory, Hobart, a small packet, on which was written "Old Tasmanian Letters from Dr. C. . . . ." It was naturally supposed they were connected with the early history of the church (St. George's, Battery Point, Hobart), in which I was much interested. I looked forward eagerly to reading them, thinking they might have to do with the dispute between Sir John Franklin and Captain Montagu over building the tower. They might contain a note from Lady Franklin when she sent her five guineas towards a peal of bells, which, alas, never materialised. They might even be part of that very willing theological controversy between Bishop Nixon and Dr. Henry Phibbs Fry!

A glance at the first letter dispelled all my hopes; the address was one from which no governor or his lady, or bishop or his clergy, was likely to write. It was a Dublin jail, and the writer was John Martin, the editor of the "Irish Felon" newspaper, who for sedition and conspiracy had been sentenced to transportation for 10 years! The letters, with the exception of one from his mother to his brother David, were all in his handwriting.

The only early connection St. George's had with Dublin was through Dr. Fry, who was a graduate of Trinity College, at which institution John Martin had begun his never completed medical course; and from the dates these two might have been there a short time together. They were certainly contemporaries in Tasmania, and it was from Dr. Fry's parish, and through one of his churchwardens, that John Mitchell, one of Martin's fellow prisoners, made his escape.

But these suppositions proved to be groundless, and a recent letter in reply to mine, from the Rev. T. Quigley, now of Felixstowe, England, states these letters were sent to him by Dr. Crossley, of Bulli, New South Wales, some years ago, who found them in his mother's house in the north of Ireland, and who wished them to be given to some society or library in Tasmania on account of their historical value.

Some people hold the opinion that any letters relating to the convict system in Tasmania are better burnt than preserved. It was a very natural and reasonable opinion for the colonists of 1852, who had fought hard and made sacrifices in order that that system should cease, but now, after the lapse of 80 years, when the sting has died out of the question, and we are able to view it more dispassionately and impersonally, in the interests of historical accuracy it is wiser that such letters should be placed in the care of some reputable society where they can be studied by those really interested. Furthermore, the period covered by these letters—1843 to 1854—is one of the most stirring and interesting in Tasmanian history, and now that the writers of fiction are getting busy with it, it is good that any records which help to produce such a well-documented novel as the Sydney one, "A House Is Built," should be preserved. A recent Tasmanian novel centres round a church and the building of a bridge. No doubt visitors to Richmond will inspect the church there, and mentally reconstruct the opening scenes of the book, quite unconscious of the fact that it was not till some 10 years after the bridge was built that the church was erected. They will then look at the present rectory, and imagine the unhappy chaplain of the story flitting through its rooms, quite unconscious also that Richmond had no resident chaplain when the bridge was built, and that the present rectory was formerly the residence of the medical superintendent!

In such a way do legends arise.

There are doubtless many letters, and even diaries, of historical interest and value stored away and half-forgotten in Tasmanian homes.

If, as is quite natural, the owners would not care to give the originals to the Royal Society, why not give copies, and start an "Historical Letter Book"? Only last year, I believe, the diary of a former chaplain at Norfolk Island was lost when the owner's house was destroyed by fire and he himself

died. A copy of such, lodged with the Royal Society, would have at least mitigated the loss.

In 1848 John Martin was a member of the Young Ireland party; a party which repudiated O'Connell's scheme for the repeal of the Union by constitutional methods, and advocated, chiefly through their newspapers, separation by force of arms.

Smith O'Brien attempted to raise the peasantry in a revolt, which failed, and he was condemned to death for treason, which sentence was afterwards commuted to transportation. John Mitchell, of the too-fluent pen, called on his countrymen to rise in "The United Irishmen," and when he was transported for sedition John Martin carried on the work in the "Irish Felon" newspaper, till he too was convicted and sentenced to transportation. The other additional members of the party who were sent to Tasmania were Meagher, McManus, O'Donohoe, and O'Doherty. Their story in Tasmania has been sympathetically told by the Rev. J. H. Cullen in "Young Ireland in Exile," and Fenton in his history has devoted a whole chapter to them, making large use of extracts from Mitchell's "Jail Journal" and letters.

John Martin came from Northern Ireland, from County Down; he was a Presbyterian, and on that account was nicknamed "John Knox" by his fellow prisoner and travelling companion, O'Doherty.

One would like to know the history of the change of an Ulsterman into a red revolutionary. He went to Dublin, to Trinity College, to study for medicine, and in the packet there is a letter to his young brother David, written, I conclude, by his mother on a visit there. She was evidently a cultured woman, for she regrets the heavy rain stopped them from going to see Trinity College library. She jestingly tells the boy she has seen the waxworks, with his favourite historical character, Henry VIII., and Elizabeth, whom he doesn't like, and later on she says he ought to be reading history with his elder sister Mary in the evenings. He must have been quite a small boy then, for she hopes that he washes and combs himself every day. It seems this mother must have died, as apparently had the father, for there is no mention of her at all in John Martin's letters; and yet this little glimpse of his Dublin student days gives a picture of happy companionship and affectionate care between mother and son.

Perhaps she was anxious for his future even then, and made this, her first, visit to Dublin for his sake, where she tells the young boy at home she has seen more people than she ever saw before, and things which will be better told by the fireside than compressed into letters.

What may be taken to be the first of John Martin's letters, for the year is not given, is written from Mount-street, Dublin, and concerns the result of an election for which the League was unprepared.

The second is headed "Richmond, Birdewill, Dublin, June 3rd, 1849," where he and his companions are awaiting sentence, and tells how news has arrived of Sir Lucius O'Brien's interview with Sir George Grey, the Colonial Under-Secretary, when he was informed that his brother, Smith O'Brien's, sentence had been commuted to transportation for life, and also that the convict ship "Mount Stewart Elphinstone" would call at Dublin that week to convey prisoners to Hobart Town, Van Diemen's Land. They had not expected to be sent so far away, and thought it more likely that they would joint Mitchell at Cape Town. As we know from the "Jail Journal," the colonists at this place refused to receive transported convicts, and Mitchell was sent on to Tasmania.

The next, a longer letter, written three weeks later, is dated from "On board the Mount Stewart Elphinstone, Cork Harbour," where the pilot had just come aboard, and he and O'Doherty were setting out for Sydney without their four other companions in exile, as they hoped.

He says:

> "We will have quite a roomy, snug cabin for reading in. The people on board are all quite civil with us. Even the poor doctor, though a ridiculous, troublesome martinet, is not desirous to annoy us, I think, but the contrary. . . . .
>
> "Our voyage is turning out expensive enough—£20 each at least—though we have all resolved to be at no expense for it. It was not on account of the quality of the food we would have as rations that we preferred making a bargain with the captain for our mess. The food that the common convicts get would be good enough I'm sure. But how could we manage to cook it, &c. Besides, we will be more civilly treated by the captain and other officials on account

of our arrangement with him. And any comfort that a little money can procure us, I have no objection to take from officials."

This paragraph is quoted to show under what comfortable conditions these two prisoners travelled, for it is often supposed they shared the hardships of those he terms "common convicts," probably transported for far less serious crimes than "sedition" and "conspiracy."

Martin's strong family affection is evidenced in this farewell letter. He hopes that David will marry, and marry young, and when writing later from Bothwell, on more than one occasion he gives the same advice—"Don't leave it too late"—"find some good girl"—"and children of course." He concludes:

> "In bidding you farewell for a few years, my dear brother, I have but to beg that you will think hopefully of me; that you will continue to make honour and principle the guide of your conduct, that you will never forget that *God sees us.* I trust to see you again, and that before many years, and to live many happy years in free intercourse with you and all the members of my family. Surely no man ever received more affectionate care and support from all the members of his family than I have from all mine. God bless you, my dear brother."

It is disappointing to find the next two letters missing: one describing the voyage, posted at Sydney, and one written to his sister Mary soon after his arrival at Bothwell, both of which he speaks of in a letter to David dated from there on 16th November, 1849.

In it he describes the township, the valley of the Clyde, the surrounding country, his lodgings at £1 a week, and his landlady, Mrs. Harris, "the friend of your friend Sairy Gamp." Though he has only been in the country a fortnight he has already found the point where the police districts of Bothwell and Oatlands touch, and at a two-storey red brick house on the Jordan, "Pleasant Place," has met O'Doherty, his companion on the voyage from Ireland.

It is somewhat surprising how these Irishmen took so easily to cross-country riding through the bush, and, as the "Jail Journal" shows, their excursions to Lake Sorell were among the happiest incidents recorded. Later on, when John Mitchell was sent to Bothwell and joined by his wife and children, the whole company moved to Nant Cottage. Mitchell

was supposed to be farming, but Martin records that he was not taking it seriously, and in the last year had put in no crops. Exciting plans for various escapes, stolen visits to other districts, news from Ireland and America, left little time for hum-drum agricultural work.

It was difficult for Martin to earn a living in a country township, and yet these men had to be sent to inland districts to lessen the possibility of escape. So he took up the only thing he could, the teaching of some of the landowners' sons, and did not find it very congenial. And here he met another strange schoolmaster, in charge of the State school in the township—" Mr. Frost, the Chartist leader, sentenced to be hanged for treason in 1839, and whose sentence was commuted to transportation. I have seen him twice," he says, " and had plenty of talk with him. He has met remarkably harsh treatment compared with ours, and yet it seems that he was always very submissive and respectful to the English Government people. It is only within three years (I think) that he has got a ticket-of-leave, and previously he was under probation like any common convict, and working on the Government road in chains. I don't understand all this. He is a stout, hale man of 63. All he begs for is a conditional pardon which would enable him to go to any place except the United Kingdom. He would go to America, and Mrs. Frost would meet him there. Is it not a striking proof of the English Government's consciousness of their iniquity against my country that they treat us sturdy Irish rebels so leniently?"

This passage is quoted in full because some people believe the Irish prisoners were very harshly treated, a belief which may have its origin in the exaggerated language of Mitchell. He frequently speaks of " our dungeon," meaning either the wide, pleasant country round Bothwell, or the whole island of Tasmania, and even before he has seen it refers to Hobart as " that metropolis of murderers, and university of burglary, and all subterhuman abomination."

In comparing Frost's sentence and treatment with theirs, one has to remember that the Chartist risings were attended with bloodshed and great destruction of property, while though Young Ireland called upon the peasantry to rise and free their country from the British yoke, the peasantry very wisely went quietly home. Also one is compelled to consider the fact that some of the Young Irelanders had influential relations in the English Parliament.

For David's information Martin gives current prices at the time of the gold rush to the mainland:

> "Draught or freight from here to Hobart Town for six or seven months is £6 to £7 a ton, the distance being 46 miles.
>
> "Draught colts £50 to £100 each, oats 16s. a bushel, potatoes £20 a ton.
>
> "The decent man, my neighbour, grumbles because he has to pay 20s. per hundred for his sheep-shearing instead of 9s. or 10s., and £40 to his shepherd instead of £18 or £20."

References to friends and relations at home, to political events in Ireland, America, and descriptions of Tasmanian scenery make up the rest of the letters.

The whole of the Irish incident in Tasmania was over in little more than five years; four of the prisoners had escaped, the rest were pardoned.

In Fenton's history, after mentioning Martin's pardon in 1854, we read: "He then went home—but to die." This is what one might call exaggerated language, as John Martin did not die till 1875, 21 years after his release, and in that time he did a good deal besides dying.

I have heard it stated, but cannot vouch for the truth, that this chapter on the Irish prisoners in Fenton's history was not written by Fenton himself, but by some one more in touch with them.

The heading of the last letter in the packet is a far cry from the township of Bothwell; it is Paris (France), 29th April, 1859, the letter of a sick and weary man, vexed with the haphazard ways of his sister's family, and "still more angry at myself for being angry."

Paris is humming with excitement, the Italian war of liberation is on, the French army is in marching order, and Martin stands outside the Tuilleries in the crowd that watches the regiments march past the Emperor. He hears the shout of "Vive L'Empereur! Vive L'Italie!" and joins in the cry from his heart.

"Vive L'Empereur!"—a strange salute from Young Ireland to the man who in the end wavered and sent his French soldiers to break Garibaldi's army at Mentana, and so delayed the trumph of United Italy!

And last of all there is an epilogue to these letters, in the form of a passport of 1867 for travelling on the Continent "for Mr. David Martin, British subject, accompanied by his wife." David had evidently listened at last to his brother's oft-repeated advice, made "the sound investment," and found "the good woman"!

The Royal Society of Tasmania

Abstract of Proceedings 1932

4TH MARCH, 1932.

Annual Meeting.

The Annual Meeting was held at the Society's Rooms, Tasmanian Museum, on the 4th March, 1932, Dr. W. L. Crowther presiding.

The following were elected Members of the Council for 1932:—Dr. A. H. Clarke, Mr. W. H. Clemes, Dr. W. L. Crowther, Mr. E. T. Emmett, Mr. V. V. Hickman, Dr. A. N. Lewis, Mr. L. Rodway, Mr. E. E. Unwin, Mr. F. E. Ward, Mr. Clive Lord *(ex officio)*.

Mr. Walter E. Taylor was elected Honorary Auditor.

Mr. S. Angel was elected a Member.

Illustrated Lecture.

Commander Moyes, of the H.M.A.S. Australia, delivered an illustrated lecture on "Recent Antarctic Exploration."

5TH APRIL, 1932.

A meeting was held at the Society's Rooms, Dr. W. L. Crowther presiding.

It was announced that the President had appointed Dr. W. L. Crowther and Dr. A. N. Lewis as Vice-Presidents for 1932.

The following Members were elected:—Mr. A. S. Johnston, Mr. H. J. Read, Mr. John Lord, Miss E. Dumaresque, Miss T. Cook, Mr. J. R. Skemp, Dr. B. Anderson, and Rev. W. T. Reeve.

The meeting was held in connection with Adult Education Week, and the following lecturettes were given:—

Tasmanian Geology—Dr. A. N. Lewis.
Tasmanian Botany—Mr. E. E. Unwin.
Tasmanian Zoology—Mr. V. V. Hickman.
Tasmanian History—Mr. Clive Lord.

16TH MAY, 1932.

A meeting was held at the Society's Rooms, Dr. A. N. Lewis presiding.

Reference was made to the death of Mr. Gustav Weindorfer, of Waldheim, Cradle Valley, and a vote of condolence passed.

The following Member was elected:—Mrs. W. L. Crowther.

Illustrated Lecture.

Mr. F. Smithies delivered an illustrated lecture on a trip to the summit of the Frenchman's Cap.

16TH JUNE, 1932.

A meeting was held at the Society's Rooms, Dr. A. N. Lewis presiding.

The following Members were elected:—Mr. D. Ockenden and Miss N. Kennedy.

An exhibition of early Tasmanian publications, maps, and sketches was held in the Library, and lecturettes on certain aspects of the exhibits were delivered by Dr. Lewis, Mr. Unwin, Mr. Henry Allport, and Mr. Lord.

11TH JULY, 1932.

A meeting was held at the Society's Rooms, Dr. W. L. Crowther presiding.

Election of Members: Mr. F. D. Maning and Miss J. Somerville.

Illustrated Lecture.

Mr. E. E. Unwin, M.Sc., delivered a lecture on "The Aquatic Habits of Insects."

8TH AUGUST, 1932.

A meeting was held at the Society's Rooms, Dr. A. N. Lewis presiding.

Illustrated Lecture.

Mr. V. V. Hickman, B.A., B.Sc., delivered a lecture on the Biology of Spiders.

12TH SEPTEMBER, 1932.

A meeting was held at the Society's Rooms, Dr. W. L. Crowther presiding.

Election of Member: Mr. D. H. Harvey.

Leonard Rodway, C.M.G.

The following resolution, moved by the Chairman, was passed:—

> "That the Royal Society of Tasmania desires to place on record its keen appreciation of the exceptional services of Mr. L. Rodway, C.M.G., in the interests of science, and an expression of deep regret that circumstances have arisen which compel Mr. Rodway to relinquish his position as Honorary Government Botanist, a post which he has held for so many years, during which he has performed services of great value to the State."

Dr. Crowther said that the value of the work done by Mr. Rodway was incalculable. His work fell under three headings—professional work as a dental surgeon; work as Government Botanist, especially in the matter of noxious weeds; and his monumental monographs on the flora and the mosses of Tasmania. His influence on the men around him, particularly the younger generation, had been marked. He had reached the highest position as a dental surgeon, but his professional work had often had to give way to his principal work, which was the science of botany. Every worker in the field of science in this State would find himself indebted to Mr. Leonard Rodway.

Dr. A. N. Lewis, M.H.A., seconded. He said he had come particularly under Mr. Rodway's influence in his younger days. The saddest feature in Mr. Rodway's resignation was that there was no one else in the whole community exactly able to fill his place.

Mr. E. E. Unwin added his personal testimony. He had come to this State nine years ago, without any knowledge of the flora of this part of the world, and had found in Mr. Rodway a generous friend and helper.

The Director of Agriculture (Mr. F. E. Ward) spoke of the very valuable help that Mr. Rodway had given to the Agricultural Department.

The motion was agreed to.

The Position of the Society.

The position of the Society was discussed, particularly in view of the fact that the Government had eliminated the vote in aid of printing the papers and proceedings of the Society.

Mr. Unwin said that he felt that a strong case could be put forward for such institutions as the Royal Society, the Tasmanian Museum, and the Botanical Gardens not being deemed charitable bodies. As such they were under a wrong classification. They should be grouped with the educational bodies of the State, which were being reduced very differently. For primary education the reduction was 3 per cent.; for the University, 2 per cent.; and for technical education less than 3 per cent. Such reductions were, of course, serious, but in proportion not so serious as in the case of the Royal Society, which had been deprived of the whole of the vote, and was faced with an acute dilemma. The Society depended upon the exchange of its publications to obtain those of learned bodies in other parts of the world. They had a very valuable library, a wonderful heritage, but it needed to be kept up to date by the inclusion of foreign publications. The membership of the Society was not large enough to carry the whole responsibility. The Royal Society of Tasmania could look back on 89 years of continuous existence. It was the only society outside the homeland with such a glorious record. They were shutting up avenues, and preventing men from doing research work. There might be other Leonard Rodways waiting for encouragement which no one could supply, because papers could not be published. There were the Royal Society medal and the Johnston Memorial medal; but they did not dare to invite learned men to speak, for they had no means of publishing the proceedings. He moved:

> "That this meeting requests the Council of the Royal Society to bring under the notice of the Government the past history of the Society in its relation to the present position of its reference library and the general position of the Tasmanian Museum."

The motion was agreed to.

Lecture.

Mr. J. D. McElroy delivered a lecture on "Oil, with special reference to its influence on commercial development."

10TH OCTOBER, 1932.

A meeting was held at the Society's Rooms, Dr. A. N. Lewis presiding.

Papers.

"Aboriginal Rock Carvings in Tasmania," Part 2, by A. L. Meston, M.A.

"Notes on the Letters of John Martin," by Mrs. J. A. McElroy.

"Notes on the Early Development of Macquarie Island," by W. L. Crowther, D.S.O., M.B.

Lecture.

Dr. Crowther delivered an illustrated lecture on Macquarie Island.

9TH DECEMBER, 1932.

A meeting was held at the Society's Rooms, Dr. A. N. Lewis presiding.

Mr. M. W. Carne was elected a Member.

The Chairman explained that the meeting had been called as the result of certain letters which had appeared in the press concerning the Botanical Gardens, and the deputation to the Government on the same matter. Members of the deputation, and critics of the present policy of the Trustees, had also been invited in order that they might place their views before the meeting.

Mr. W. H. Clemes, Chairman of Trustees, gave a resume of the proceedings which had led up to the present position. He explained in detail the position of the Gardens and the policy of the Trustees. He pointed out that the Trustees were endeavouring, in spite of their very limited financial resources, to make the Botanical Gardens a Botanical Garden in effect as well as in name. After dealing with all aspects of the present position, Mr. Clemes moved:

> "That this Society approves of the actions of its representatives on the Board of Trustees, which have the approval and confirmation of this meeting."

The resolution was seconded by the Hon. L. M. Shoobridge, M.L.C. Dr. E. A. Elliott, Messrs. N. Oldham, and

W. Osborne, members of the deputation to the Government, gave their views on the matter. Mr. I. Boas, M.Sc., Chief Forestry Officer for the Council of Scientific and Industrial Research, was invited by the Chairman to speak. Mr. Boas said that during the course of his visit to Hobart he had examined the Botanical Gardens, and had formed the opinion that the Trustees were acting on correct lines. If anything a more extensive trimming of the overcrowded section should be carried out. The criticism was not justified.

Messrs. E. E. Unwin, E. T. Emmett, A. V. Giblin, F. E. Ward, S. W. Steane, C. Lord, and Drs. Crowther and Lewis also spoke.

The general tenor of the discussion showed clearly that the Trustees' policy was a distinct benefit to the Gardens, and had the approval of botanical experts. Further, it was clear that the criticisms which had been made were based upon a want of knowledge of the true conditions. The resolution expressing confidence in the Trustees, and approval of their actions, was carried without a dissenting vote.

The Royal Society of Tasmania
1932

Patron:
HIS MAJESTY THE KING.

President:
HIS EXCELLENCY SIR HERBERT NICHOLLS, K.C.M.G.

Vice-Presidents:
W. E. L. CROWTHER, D.S.O., M.B., V.D.
A. N. LEWIS, M.C., LL.D.

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(Elected March, 1932)

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A. H. CLARKE, M.R.C.S., L.R.C.P.
W. E. L. CROWTHER, D.S.O., M.B., V.D.
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L. RODWAY, C.M.G.
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F. E. WARD

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Auditor:
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Secretary and Librarian:
CLIVE LORD.

List of Members

Honorary Members.

David, Sir T. Edgeworth, K.B.E., C.M.G., B.A., F.R.S., F.G.S., Emeritus Professor of Geology and Physical Geography in the University of Sydney, 49 Burdett Street, Hornsby, N.S.W.

Mawson, Sir Douglas, Kt., O.B.E., B.E., D.Sc., F.R.S., Professor of Geology and Mineralogy, The University, Adelaide.

Wood-Jones, Professor F., M.D., D.Sc., M.R.C.S., L.R.C.P., F.R.S., The University, Melbourne.

Tillyard, R. J., M.A., Sc.D. (Cantab.), D.Sc., F.R.S., F.N.Z. Inst., F.L.S., F.G.S., F.E.S., C.M.Z.S., Chief of the Division of Economic Entomology, C.S.I.R., Canberra City, F.C.T.

Corresponding Members.

Year of Election.	
1901	Benham, W. B., M.A., D.Sc., F.R.S., F.Z.A., Professor of Biology, The University of Otago, Dunedin, N.Z.
1892	Bragg, Sir W. H., M.A., F.R.S., Director of the Royal Institution, Albemarle Street, London.
1901	Chapman, Professor R. W., M.A., B.C.E., The University, Adelaide.
1923	Pulleine, R., M.B., 163 North Terrace, Adelaide.
1892	Thomson, Hon. G. M., M.L.C., F.L.S., 99 Eglinton Road, Dunedin.
1901	Wall, Professor A., M.A., Canterbury College, Christchurch.

Life Members.

1918	Avery, J., Private Bag, Hobart.
1809	Baker, H. D., American Consular Service, Washington.
1890	Foster, Lt.-Colonel Henry, "Merton Vale," Campbell Town.
1905	Grant, C. W., Senator, "High Peak," Huon Road.
1896	Sprott, G., M.D., Town Hall, Hobart.

Year of Election.	Members.
1931	Agnew, Mrs., 2 Waverley Avenue, Augusta Road, New Town.
1921	Anderson, G. M., M.D., C.M., 56 Clare Street, New Town.
1921	Allen, D. V., B.Sc., Technical School, Launceston.
1928	Allport, Henry, LL.B., 111 Macquarie Street, Hobart.
1932	Angel, S., Commercial Bank of Aust., Hobart.
1926	Atkins, C. N., M.B., B.S., D.P.H., 145 Macquarie Street, Hobart.
1928	Avery, David, Geeveston, Tasmania.
1921	Baker, Hon. H. S., LL.M., D.S.O., Messrs. Finlay, Watchorn, Baker, and Turner, Murray Street, Hobart.
1921	Barr, J. Stoddard, M.D. (Glasgow), Lower Sandy Bay.
1926	Barrett, Rev. W. R., Christ College, Park Street, Hobart.
1929	Baudinet, Miss D., 336 Murray Street, Hobart.
1931	Bell, Miss D., 302 Argyle Street, Hobart.
1924	Bennett, H. W., L.D.S., D.D.S., Brisbane Street, Launceston.
1909	Blackman, A. E., 26 Warwick Street, Hobart.
1920	Blaikie, T. W., Practising School, Elizabeth Street, Hobart.
1927	Blake, Frank, Red Chapel Road, Lower Sandy Bay.
1928	Bowling, J., "Barrington," Tower Road, New Town.
1924	Booth, N. P., Messrs. Cadbury-Fry-Pascall Ltd., Claremont.
1925	Bowerman, Captain, Marine Board, Hobart.
1923	Breaden, J. C., 12 Waverley Avenue, New Town.
1922	Brownell, C. C., 117 Hampden Road, Battery Point.
1907	Brownell, F. L., "Berwyn," Mercer Street, New Town.
1928	Buchanan, Howard, E.S. and A. Bank, Hobart.
1929	Burbury, A. W., M.H.A., Austin's Ferry.
1918	Burbury, Charles, "Brookside," Moonah.
1925	Butler, A. L., Lower Sandy Bay.
1931	Butler, C. T., Red Chapel Road, Sandy Bay.

Year of Election.

1923 Butler, Mrs. G. H., 30 Augusta Road, New Town.

1930 Butler, Terence, M.R.C.S., L.R.C.P., Macquarie Street, Hobart.

1909 Butler, W. F. D., B.A., M.Sc., LL.B., Bishop Street, New Town.

1931 Campbell, C. J., 135 King Street, Sandy Bay.

1920 Cane, F. B., 90 High Street, Sandy Bay.

1932 Carne, W. M., 64 York Street, Sandy Bay.

1929 Chambers, V. I., LL.B., 22 Murray Street, Hobart.

1929 Chapman, G. T. F., 212 Davey Street, Hobart.

1928 Chapman, Miss Joi, 212 Davey Street, Hobart.

1931 Chepmell, C. H. D., Legislative Council, Hobart.

1927 Cherry, P. J., Burnie.

1920 Clark, W. I., M.B., Macquarie Street, Hobart.

1896 Clarke, A. H., M.R.C.P., L.R.C.P., "Private Secretary's Cottage," The Domain, Hobart.

1918 Clarke, T. W. H., "Quorn Hall," Campbell Town.

1910 Clemes, W. H., B.A., B.Sc., Clemes College, New Town.

1931 Clemes, Miss Joan, Clemes College, New Town.

1922 Collier, J. D. A., The Tasmanian Public Library, Hobart.

1932 Cook, Miss T., 6 Boa Vista Road, New Town.

1927 Cooper, S. G., 5 Main Road, New Town.

1931 Cox-Taylor, Colonel J. H., D.S.O., St. Helens, Tasmania.

1930 Crace-Calvert, W. F., 32 View Street, Sandy Bay.

1930 Crane, J. R., 17 Darcy Street, Hobart.

1911 Crowther, W. E. L., D.S.O., V.D., M.B., Macquarie Street, Hobart.

1932 Crowther, Mrs. W. E. L., "Coreen," Macquarie Street, Hobart.

1918 Cummins, W. H., A.I.A.C., The Telegraph Newspaper Co., Brisbane.

1927 Dallas, K. M., The University, Hobart.

1919 Davies, H. Warlow, 22 Augusta Road, New Town.

Year of Election.

1924 Davies, G. B., 111 Patrick Street, Hobart.

1908 Dechaineux, L., Technical College, Hobart.

1932 Dumaresq, Miss E., Alexandra Hospital, Hobart.

1919 Elliott, E. A., M.B., Ch.M., Main Road, New Town.

1921 Emmett, E. T., Director of Tasmanian Government Tourist Bureau.

1918 Evans, L., Department of Agriculture, Hobart.

1931 Evans, G. H., Hydro-Electric Commission, Hobart.

1921 Exley, H. J., Box 67E, G.P.O., Hobart.

1921 Eyre, H., Boys' Welfare School, Elizabeth Street, Hobart.

1921 Fox, Miss, Ladies' College, Launceston.

1930 Fox, Stanley, 131 Macquarie Street, Hobart.

1918 Fletcher, C. E., M.A., Education Department, Hobart.

1928 Foley, J. C., Weather Bureau, Hobart.

1921 Forward, J. R., Public Library, Launceston.

1927 Gellibrand, W. T., "Lachlan Vale," The Ouse, Tasmania.

1922 Giblin, A. V., King Street, Sandy Bay.

1923 Gorringe, J. A., Kempton, Tasmania.

1926 Giblin, R. W., F.R.G.S., F.R.C.I., 69 Courtfield Gardens, London, S.W.

1921 Giblin, W. W., C.B., V.D., M.R.C.S., L.R.C.P., Macquarie Street, Hobart.

1908 Giblin, Major L. F., D.S.O., B.A., Ritchie Professor of Economics, The University, Melbourne.

1931 Gibson, Stuart G., M.B., B.Sc., Macquarie Street, Hobart.

1930 Giles, L., 80 Collins Street, Hobart.

1932 Grace, W. L., B.A., Dip. Ed., F.R.G.S., M.R.S.T., 6 Mortimer Avenue, New Town.

1930 Graham, W., The Grange, Brown's River Road.

1927 Grant, H. N., The Tasmanian Club, Hobart.

1929 Grueber, F. W., 71 Arthur Street, Hobart.

1928 Gunn, Miss I., "Invercarron," Broadmarsh, Tasmania.

1924 Hall, E. L., 38 Lyttleton Street, Launceston.

Year of Election.

1922 Halligan, G. H., F.G.S., "Uplands," Station Street, Pymble, N.S.W.

1931 Hamilton, Bruce, M.B., Ch.M., Macquarie Street, Hobart.

1918 Harrap, Lt.-Colonel G., Launceston.

1932 Harvey, D. H., "Colwyn," 38 Main Road, Sandy Bay.

1931 Harvey, R. C., 115 King Street, Sandy Bay.

1919 Hay, Rt. Rev. R. S., D.D., "Bishopscourt," Hobart.

1931 Hawker, Mrs., 10 Elboden Street, Hobart.

1924 Heritage, F. W., Collins Street, Hobart.

1921 Heritage, J. E., Frederick Street, Launceston (3 St. Canice Road, Sandy Bay).

1921 Heyward, F. J., F.R.V.I.A., 43 Lyttleton Street, Launceston.

1915 Hickman, V. V., B.A., B.Sc., 69 Cross Street, New Town.

1914 Hitchcock, W. E., 89 Balfour Street, Launceston, Tasmania.

1918 Hogg, G. H., M.D., C.M., 37 Brisbane Street, Launceston.

1931 Hughes, T. D. H., Court of Requests, Launceston.

1923 Hungerford, Mrs., "Hathaway House," Holebrook Place, Hobart.

1909 Hutchison, H. R., 1 Barrack Street, Hobart.

1932 Hytten, Professor T., M.A., The University, Hobart.

1928 Ireland, F. W. J., M.B., C.M., Macquarie Street, Hobart.

1919 Jackson, G. A., 97 Collins Street, Hobart.

1929 Jaques, G. A., Union Bank, Hobart.

1906 Johnson, J. A., M.A., Teachers' College, Hobart.

1929 Johnson, Norman, Athenæum Club, Hobart.

1929 Johnson, W. R., Clemes College, New Town.

1932 Johnston, A. S., The Friends' School, Hobart.

1922 Johnston, J. R., Murray Street, Hobart.

1922 Kemp, Andrew, Stoke Street, New Town.

1930 Kemp, E. D. F., Earl Street, Sandy Bay.

Year of Election.

1924 Kennedy, J., 96 Montpelier Road, Hobart.

1924 Kennedy, Mrs. J., 96 Montpelier Road, Hobart.

1932 Kennedy, Miss N., 174 Macquarie Street, Hobart.

1927 King, C. S., 12 Swanston Street, New Town.

1927 Kirby, E. R., 13 Mortyn Avenue, Hobart.

1918 Knight, C. E. L., Claremont.

1927 Knight, F. C. E., Claremont.

1913 Knight, J. C. E., Claremont.

1931 Lane, Lt.-Colonel D. A., V.D., Forestry Department, Hobart.

1924 Legge, R. W., Cullenswood, Tasmania.

1887 Lewis, Sir N. E., K.C.M.G., M.A., B.C.L., LL.B., Augusta Road, Hobart.

1919 Lewis, A. N., M.C., LL.D., "Abernant House," Holebrook Place, Hobart.

1928 Lewis, Mrs. A. N., "Abernant House," Holebrook Place, Hobart.

1926 Lindon, Mrs. L. H., "Waimu," Canice Road, Sandy Bay.

1912 Lord, Clive E., F.L.S., C.M.Z.S., "Telopea," Quorn Street, Sandy Bay.

1927 Lord, Graham, Vacuum Oil Company, Hobart.

1930 Lord, Colonel J. E. C., C.M.G., V.D., Police Department, Hobart.

1932 Lord, John, F.C.A. (Aust.), 41 Sandy Bay Road.

1923 McAulay, Professor A. L., Ph.D., The University, Hobart.

1927 Mace, Miss V. E., "The Pottery," Bothwell.

1927 Macfarlane, Charles, State High School, Hobart.

1923 Macfarlane, Mrs. C., 3 Montague Avenue, New Town.

1928 McElroy, J. D., 32 Bellevue Parade, New Town.

1930 McIntyre, J. A. L., Wentworth Street, South Hobart.

1922 Macleod, Mrs. L. H., 67 High Street, Sandy Bay.

1919 McKay, A. D., 26 High Street, Launceston.

1932 Manning, F. D., 48 Fitzroy Place, Hobart.

1918 Mansell, A. E., Bruny Island.

Year of Election.

1924 Marsh, James, Messrs. Cox, Kay Pty. Ltd., Collins Street, Hobart.

1918 Martin, Brigadier-General W., Launceston.

1931 Masters, W. E., Messrs. Tinning, Propsting, and Masters, Hobart.

1921 Masters, A. H., Forest Road, Trevallyn, Launceston.

1929 Mattingley, P. F. C., B.D.S., L.D.D., 36 Brisbane Street, Launceston.

1930 Maxwell, C. M., E.S. and A. Bank, Hobart.

1926 Meredith, David, Electrolytic Zinc Company, Risdon.

1927 Meredith, Mrs. David, 107 High Street, Sandy Bay.

1921 Meston, A. L., M.A., High School, Launceston.

1909 Millen, Senator J., "Roxburgh," Newstead, Tasmania.

1930 Mitchell, E. C., "Bayswater," Sandy Bay.

1907 Miller, R. O. M., 6 Main Road, New Town.

1911 Montgomery, R. B., 303 Davey Street, Hobart.

1927 Morris, J. M., The Union Bank, Hobart.

1918 Murdoch, Honourable T., M.L.C., 55 Montpelier Road, Hobart.

1929 Murray, J. F., Federal Taxation Department, Hobart.

1931 Murray, J., The Tasmanian Club, Macquarie Street, Hobart.

1921 Muschamp, Rev. E., Holy Trinity Rectory, Launceston.

1933 Nicholas, Miss Doris A., "Millbrook," Ouse.

1882 Nicholas, G. C., "Cawood," The Ouse, Tasmania.

1918 Nicholls, Sir Herbert, K.C.M.G., Pillinger Street, Sandy Bay.

1910 Nicholls, H. M., Department of Agriculture, Hobart.

1921 Nye, P. B., B.M.E., Mines Department, Hobart.

1932 Ockenden, D., Central Avenue, Moonah.

1921 Oldham, W. C., 39 George Street, Launceston.

1924 Oliver, H., Lindisfarne.

1931 Onslow, G. F., 270 Davey Street, Hobart.

1927 Orme, K., 76 York Street, Sandy Bay.

Year of Election.

1921 Overell, Miss L., Holebrook Place, Hobart.

1921 Padman, R. S., 56 St. John Street, Launceston.

1923 Parker, H. T., "Montana," Bellerive.

1921 Patten, W. H., 59 Cameron Street, Launceston.

1931 Patterson, Mrs. R. C., "Varuna," Holebrook Place, Hobart.

1929 Pearce, Harold, Ellington Road, Lower Sandy Bay.

1923 Pedder, A., "Sherborne," Upper Argyle Street, Hobart.

1927 Penman, C. J., Smelting Works, Launceston.

1930 Perkins, Mrs. C. H., 16 Turner Street, Fitzroy Place, Hobart.

1902 Piesse, E. L., B.Sc., LL.B., "Merridale," Sackville Street, Kew, Melbourne.

1910 Pillinger, J., 4 Fitzroy Crescent, Hobart.

1926 Pitman, Professor E. J. G., B.A., B.Sc., The University, Hobart.

1925 Propsting, G. L., Earl Street, Sandy Bay.

1931 Rait, W. L., B.Sc., 20 Fitzroy Place, Hobart.

1927 Raymond-Barker, A. B., Darcy Street, Hobart.

1930 Read, Mrs. Ronald, Wellwood Street, Lenah Valley.

1929 Read, D. W., The University, Hobart.

1932 Read, H. J., The Friends' School, Hobart.

1932 Reeve, Rev. W. T., St. John's Rectory, Goulburn Street, Hobart.

1931 Reid, Miss A. K., 338 Murray Street, Hobart.

1921 Reid, A. McIntosh, 270 Davey Street, Hobart.

1925 Reid, Miss M. L., The University, Hobart.

1931 Rex, M., 7 Mona Street, Battery Point.

1921 Rex, R. R., 7 Mona Street, Battery Point.

1931 Reynolds, B. R., 176 Collins Street, Hobart.

1928 Richardson, F. B., 60 Augusta Road, New Town.

1925 Robinson, F. G., 83 Princes Street, Sandy Bay.

1926 Robson, Mrs., Elphin Road, Launceston.

1929 Roche, M. M., Lands' Titles Department, Hobart.

Year of Election.

1884 Rodway, L., C.M.G., The Botanical Gardens, Hobart.

1921 Rolph, W. R., "The Examiner" and "Courier" Office, Launceston.

1931 Ross, Hector, Cambridge, Tasmania.

1931 Rowlands, J. E. A., Public Trust Office, Hobart.

1922 Sargison, H., Elizabeth Street, Hobart.

1931 Scott, E., Queen Victoria Museum, Launceston.

1896 Scott, H. H., Queen Victoria Museum, Launceston.

1930 Scott, J. B., 5 Greenlands Avenue, Sandy Bay.

1928 Scott, R. A., Department of Agriculture, Hobart.

1896 Scott, R. G., M.B., 172 Macquarie Street, Hobart.

1921 Shields, Hon. Tasman, M.L.C., 13 Paterson Street, Launceston.

1925 Shoobridge, K., Glenora, Tasmania.

1921 Shoobridge, Hon. L. M., "Sunnyside," New Town.

1925 Shoobridge, Rupert, "Fenton Forest," Glenora.

1923 Shoobridge, S. E., Messrs. Oscar Smith & Co., Macquarie Street, Hobart.

1927 Shugg, A. W., M.B., B.S., 174 Macquarie Street, Hobart.

1923 Simson, Mrs. C. J., 3 St. George's Square, Launceston.

1932 Somerville, Miss J., Wellington Square School, Launceston.

1932 Skemp, J. R., "Reediford," Myrtle Bank, Tasmania.

1927 Smith, Miss M., c/o The Countryman, 4 St. James' Buildings, 123 William Street, Melbourne, C1.

1921 Smithies, F., 34 Paterson Street, Launceston.

1925 Stackhouse, C. K. R., LL.B., 55 Paterson Street, Launceston.

1930 Steane, S. W., Conservator of Forests, Hobart.

1928 Steele, R. B., Department of Agriculture, Hobart.

1929 Stephens, C. G., The University, Hobart.

1920 Swindells, A. W., c/o Messrs. Murdoch Bros., Market Place, Hobart.

1927 Tankard, L. W., Sheffield, Tasmania.

1918 Taylor, W. E., Elboden Street, Hobart.

Year of Election.

1931 Thwaites, J. B., Glenorchy.

1930 Travers, Miss C., Fisher's Avenue, Lower Sandy Bay.

1930 Travers, Miss I., "Nateby," Lower Sandy Bay.

1929 Thirkell, Major R. W., O.B.E., V.D., 405 Elizabeth Street, Hobart.

1929 Thomas, A. J. M., Short Street, The Glebe, Hobart.

1923 Thomas, J. F., Room 8, Wilga Chambers, 158 Philip Street, Sydney.

1922 Thompson, E. H., Lower Sandy Bay.

1931 Townley, D. G., 5 Waverley Avenue, New Town.

1928 Tribolet, D. R., Mount Stuart Road, Hobart.

1927 Turner, A. Jefferies, M.D., F.E.S., Wickham Terrace, Brisbane.

1928 Turner, J. W., Lt.-Colonel, V.D., Mona Street, Battery Point.

1923 Unwin, E. E., M.Sc., The Friends' School, Hobart.

1931 Usher, F., The Mercury Office, Hobart.

1930 Walch, Christine, M.B., Ch.M., 171 Macquarie Street, Hobart.

1927 Walch, J. H. B., M.B., 71 Crescent Road, Hobart.

1918 Walch, P. B. C., King Street, Sandy Bay.

1928 Walters, Rev. Walter, Scottsdale, Tasmania.

1931 Wallace, A. C., 140 Collins Street, Hobart.

1926 Ward, F. E., Director of Agriculture, Hobart.

1931 Waterworth, E., Poet's Road, Hobart.

1926 Waugh, E. C., LL.B., Waimea Avenue, Sandy Bay.

1922 Wayn, Miss A. L., c/o The Chief Secretary's Office, Hobart.

1930 Webster, E. H., "Greystanes," Red Chapel Road, Sandy Bay.

1927 Wells, F., Sandown, Lower Sandy Bay.

1929 White, G. L., The University, Hobart.

1926 Whittle, B. H., Augusta Road, New Town.

1925 Winch, M., c/o Brownell Bros. Ltd., Hobart.

1901 Wise, H. J., 13 Lord Street, Sandy Bay.

1927 Whishaw, R., M.B., Ch.M.. Macquarie Street, Hobart.

Annual Report
1932

The Council and Officers.

The Annual Meeting was held at the Society's Rooms, The Tasmanian Museum, Hobart, on 4th March, 1932.

The following were elected as Members of the Council for 1932:—Dr. A. H. Clarke, Mr. W. H. Clemes, Dr. W. L. Crowther, Mr. E. T. Emmett, Mr. V. V. Hickman, Dr. A. N. Lewis, Mr. L. Rodway, Mr. E. E. Unwin, Mr. F. E. Ward, and Mr. Clive Lord *(ex officio)*.

The Council at its first meeting made the following appointments:—

Chairman of the Council: Mr. W. H. Clemes, B.A., B.Sc.

Secretary: Mr. Clive Lord.

Hon. Treasurer: Dr. A. N. Lewis.

Standing Committee: Messrs. Clemes, Lord, and Dr. Lewis.

Representatives of the Society on the Board of Trustees of the Tasmanian Museum and Botanical Gardens: Mr. W. H. Clemes, Dr. A. H. Clarke, Dr. W. L. Crowther, Dr. A. N. Lewis, Mr. E. T. Emmett, and Mr. E. E. Unwin.

Meetings.

Ten meetings were held, and in addition to the lectures delivered, scientific papers of considerable interest and value were submitted.

(See abstract of meetings for titles of lectures, papers, &c.)

The Library.

The Society's library continues to be of outstanding service, not only to members, but as a source of reference on scientific matters generally, and in this regard is an important factor in the general progress of the State. The removal to larger quarters has been of distinct advantage,

R. M. JOHNSTON MEMORIAL.

THE R. M. JOHNSTON MEMORIAL MEDAL.

List of Awards:

1923 Sir J. W. Edgeworth David, K.B.E., C.M.G., F.R.S., F.G.S.

1925 Professor F. Wood-Jones, M.B., B.S., M.R.C.S., L.R.C.P., D.Sc.

1929 R. J. Tillyard, M.A., Sc.D. (Cantab.), D.Sc., F.R.S., F.N.Z. Inst., F.L.S., &c.

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but funds do not permit the cataloguing and binding to be kept as up to date as might be wished.

Natural Sciences.

Reference was made in last year's report to the need for more attention being given to the natural sciences in Tasmania, and the fact that the Society had brought the matter under the notice of the Government.

The importance of the matter has been realised, and the Council is pleased to report that its efforts to have more attention paid to the natural sciences are bearing fruit.

The Botanical Gardens.

The Council became concerned owing to certain criticisms made in regard to the policy of the Trustees of the Botanical Gardens, and in order to investigate the matter a special meeting of the Society was held in order to receive a report from the Society's representatives on the Trust, and an invitation was extended to the critics to attend. After a full discussion a resolution expressing confidence in the action of the Trustees was carried unanimously.

Finance.

The financial position of the Society has been the cause of very considerable concern. The elimination of the Government grant, together with the reduction in the number of members consequent upon the general economic depression, has made the publication of the papers and proceedings a difficult matter. In view of the fact that the Library depends for its exchanges upon the publication of the papers and proceedings, and the work generally that the Society is doing on behalf of the State, the Council is approaching the Government with regard to the publication of the Papers and Proceedings for 1932.

The accounts, as published, should be read with the understanding that there are outstanding accounts amounting to approximately £125, including £100 owing on the printing of the 1931 papers and proceedings. This debt will be met out of 1933 subscriptions, but unless outside support is obtained it is difficult to know when the volume for 1932 will be published.*

* Since the above report was compiled the Premier has kindly agreed to assist the Society by printing the 1932 volume.

The credits shown in the Memorial Fund are due to the fact that the purchase of books was held up during the currency of the Commonwealth Government's sales and primage tax. Now that this has been lifted education societies such as this are once more free to import books without excessive taxation being added to already high costs.

BRANCH AND SECTION REPORTS.

The Northern Branch carried on its usual operations during the year.

The only section of the Society which held regular meetings and discussion was the Education Section, which met regularly during the term under review.

THE ROYAL SOCIETY OF TASMANIA MEDAL.

List of Awards:

1927 L. Rodway, C.M.G.
1930 Clive Lord, C.M.Z.S., F.L.S., F.R.A.I.A.

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NATIONAL MUSEUM
VICTORIA.

THE ROYAL SOCIETY OF TASMANIA.

GENERAL FUND.

STATEMENT OF RECEIPTS AND EXPENDITURE, 1932.

RECEIPTS.	£	s.	d.
Balance brought forward	14	14	4
Subscriptions	187	19	0
Rent of room	18	1	0
Sale of publications and reprints	17	14	2
	£238	8	6

EXPENDITURE.		£	s.	d.
Salaries and wages		35	8	8
Papers and proceedings—				
1930 (part)	£80 0 3			
1931 (part)	51 17 6			
		131	17	9
General printing		20	2	2
Library		20	11	10
Northern Branch		8	8	0
Light and fuel		3	8	6
Insurance		5	18	9
Miscellaneous		4	10	2
Petty cash		8	1	5
Bank charges		0	0	3
		238	6	10
Carried forward (31.12.32)		0	1	8
		£238	8	6

Examined and certified to be correct.

WALTER E. TAYLOR, F.F.I.A.,

Hon. Auditor.

23rd February, 1933.

A. N. LEWIS, Hon. Treasurer.

CLIVE E. LORD, Secretary.

11th January, 1933.

THE ROYAL SOCIETY OF TASMANIA.

R. M. JOHNSTON FUND, 1932.

RECEIPTS.	£ s. d.	PAYMENTS.	£ s. d.
Balance brought forward (1.1.32)	0 18 6	Amount carried forward (31.12.32)	7 14 5
Interest received from Perpetual Trustee Co.	6 15 11		
	£7 14 5		£7 14 5

Examined and certified to be correct.
WALTER E. TAYLOR, F.F.I.A.,
Hon. Auditor.
23rd February, 1933.

A. N. LEWIS, Hon. Treasurer.
CLIVE E. LORD, Secretary.
11th January, 1933.

MORTON ALLPORT MEMORIAL FUND, 1932.

RECEIPTS.	£ s. d.	PAYMENTS.	£ s. d.
Balance brought forward (1.1.32)	4 19 9	Book for Library	0 12 6
Interest received from Perpetual Trustee Co.	6 15 8	Balance carried forward (31.12.32)	11 2 11
	£11 15 5		£11 15 5

Examined and certified to be correct.
WALTER E. TAYLOR, F.F.I.A.,
Hon. Auditor.
23rd February, 1933.

A. N. LEWIS, Hon. Treasurer.
CLIVE E. LORD, Secretary.
11th January, 1933.

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